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COMPUTER SYSTEM MAINTENANCE AND ENHANCEMENTS

BATTELLE MEMORIAL INSTITUTE
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AIR FORCE WRIGHT AERONAUTICAL LABORATORIES
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Battelle has supported the Air Force Compressor Research Facility from February 1984, through July 30, 1988, under this contract. The work performed by Battelle included support to the entire computer and information subsystem at the Compressor Research Facility located on Wright-Patterson Air Force Base. The work was largely computer related; it entailed writing new software, modifying old software, purchasing, and integrating off-the-shelf software packages. The work also included purchasing of computer equipment and other hardware, helping the Air Force staff minimum manning positions during compressor testing, and training Air Force personnel in the use of newly developed software.

During this contract Battelle performed many tasks, including software development efforts and extensive research resulting in system definitions. The tasks varied in size and duration, the largest two being Support to Facilities and Main Computer Support, which ran throughout the duration of the contract. The small tasks usually involved reviewing existing software or hardware, solving a specific problem or making modifications to

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FINAL REPORT ABSTRACT FOR

COMPUTER SYSTEM MAINTENANCE AND ENHANCEMENTS

CONTRACT NO. F33615-83-C-2382

TO

UNITED STATES AIR FORCE

AIR FORCE SYSTEMS COMMAND / AIR FORCE WRIGHT AERONAUTICAL LABORATORIES

Battelle has provided facility support at the Air Force Compressor Research Facility from May 1983 to July 1988. The work performed included support to many components of the Compressor Research Facility located at Wright-Patterson Air Force Base. The work was largely computer related, entailing the development, modification, and enhancement of data acquisition and control software, as well as the procurement of off-the-shelf software packages. The scope of the contract also included purchasing computer equipment and other hardware, helping the Air Force staff minimum manning positions during compressor testing, and training Air Force personnel to use newly developed software.

Throughout this contract Battelle performed many tasks. Some required extensive research before software was written or a computer system purchased. Other tasks involved reviewing existing software or hardware, to solve a problem or make a modification.

Battelle developed systems to perform drive system simulation, data acquisition and storage, test article control, valve control, color graphics, post processing and analysis, facility simulation, operating system upgrades, computer communications, calibration, tuning, and digitizing.

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INTRODUCTION

This final report summarizes the tasks performed by Battelle under contract number F33615-83-C-2382. Through the use of this contract Battelle provided facility support for the computer systems used in the research and development (R&D) facilities of the Technology Branch, Turbine Engine Division, Air Force Wright Aeronautical Laboratories (AFWAL) at Wright-Patterson Air Force Base.

SCOPE

Battelle provided maintenance and enhancement support of Technology Branch R&D facility software and related automated data processing equipment (ADPE) devices. Areas of support included facility and test article control, data acquisition, facility and test article simulation, operator interface, data processing, documentation, and operating system upgrades. The effort involved work performed "off site" at Battelle's Columbus Laboratory and "on site" at the Aero Propulsion Laboratory's Compressor Research Facility (CRF).

BACKGROUND

The mission of the Technology Branch is to conduct research and development on gas turbine engine compressors. The actual testing of compressors is performed in the Branch's Compressor Research Facility (CRF). The test article is driven by one of two 30,000 hp synchronous electric motors, coupled by a gearbox system that can increase test article speed up to 30,000 rpm. The drive motor power conditioning is accomplished by a complex arrangement of motors, generators, and a line frequency converter. The test article is mounted in a test tunnel 20 feet in diameter and 65 feet in length with inlet and discharge valves to permit control of compressor ratio and flow.

Computer control of all systems allows detailed study of the test article by means of online data analysis. The drive motor speed, power conditioning, inlet and discharge valves and variable test article geometry are all digitally controlled by Modcomp computers. Test article lubrication, drive motor lubrication, actuator hydraulics, service air, cooling water and auxiliary air systems are controlled by programmable logic controllers (PLC), whose software is an emulation of relay ladder networks. Seven Modcomp computers are used for control, data acquisition, and operator interface. Facility and test article control is performed by four of the Modcomps (FCC1, FCC2, TAC1, and TAC2) which communicate through shared memory. Online transducer calibration and data acquisition is performed by the DAC computer which then sends data through the auxiliary computer (AUX) to the IBM (Main). The Main performs data acquisition control, data reduction and analysis, data display, and offline support functions. Operator interface is performed by the Monitor computer. It allows the operator to give commands to the control computers and the DAC, and also receives data from them which is stored on historical tapes and displayed to the operator using Ramtek graphics generators.

The simulator computer is a Modcomp Classic. It digitally simulates the facility and the PLCs in real time and provides feedback to the control computers. Functionally, the operators see no difference between a real and a simulated test run. The simulator's functions are to validate software and to train facility operators. For the validation function, all applications software in the CRF facility computers must be kept identical to that of the real system. This is accomplished through the modification of operating system's device handlers to route control and feedback input/output (I/O) to the simulator computer.

This contract included the eleven tasks listed below:

Task A - Support to Facilities
Task B - Simulator Support
Task C - Completion of Simulator
Task D - Data Acquisition System Support
Task E - Monitor Computer Operating Systems Upgrade
Task F - Online Diagnostics
Task G - PLC Simulation
Task H - Graphics Response Time
Task I - Frequency Converter Control
Task J - Software Configuration Maintenance Support System
Task K - Main Computer Support

The following Battelle personnel worked on this project; D. Engler, D. Haller, D. Hughes, R. Daniel, P. Teets, G. Potter, R. Finkbine, R. Luce, W. Kaiser, M. Zelinski, M. Koenig, R. Byers, W. Drozda, N. Tenuta, C. Jones, M. Heltzel, C. Derringer, D. Molnar, J. Pittenger, N. Ackgerman, R. Mazey, K. Schrieber.

In the sections that follow, each task is addressed in three parts. The first is an overview that gives background and general information about the task. The second is the requirements for the task as stated in the contract. The third describes accomplishments on the task and the results obtained (e.g., software written, support given, people trained). The numbers in parentheses associated with the various tasks and subtasks refer to specific paragraphs in the contract.

TASK A - SUPPORT TO FACILITIES (4.1)

OVERVIEW

The facilities in the Technology Branch require continuing software and hardware maintenance to keep them operational. The facilities are designed to be versatile; however, each new test article requires modifications to software and interfaces, and often requires the addition of new functions. The computers interface to many pieces of equipment. When this equipment was added, deleted, upgraded, or modified, software and computer interfaces often required a corresponding adjustment. Occasionally, while running the facility, it is determined that software modifications were required because a function did not meet its specification or the specification did not meet the needs. There were many cases where improvements were made to increase the efficiency of the facility operation. The software maintenance ranged from small "one-line" changes to complete redesign and rewriting of large sections of code. This work included support of closed loop digital control; data acquisition, reduction, and storage; transducer calibration, device handlers, operating systems, database management, communications, and PLC relay ladder diagrams. The facility software is very critical, with high interaction between modules among all the computers. For this reason, all maintenance and enhancement work was performed with prior approval of the Air Force.

The specific requirements, Battelle's efforts, and the results achieved are detailed by subtask in the subsections that follow.

Maintain and Repair Software (4.1.1)

REQUIREMENTS

The contractor shall maintain and repair software in the Branch facilities as approved by the Air Force project engineer or his designee. The Air Force will supply the CRF Operations and Maintenance (O&M) Manual to the contractor. The contractor shall update the CRF O&M Manual as required to keep it current as a result of the contractor's maintenance and repair work.

BATTELLE ACTIONS AND RESULTS

Documentation and Training

Battelle staff created and updated documentation related to the tasks and subtasks performed under this contract. Computer user notes, operator notes, and CRF Operation and Maintenance documentation were updated.

Battelle staff developed a new outline and structure for CRF documentation based on the original Cadre and vendor documentation, CRF design notes, and acceptance test procedures. As new documentation was generated, it was written to comply with the new structure and format. Some of the existing documentation was converted to the new format.

Training was provided, at Battelle's expense, for Battelle on site employees to enhance skills necessary to efficiently accomplish tasks related to testing. Masscomp (Unix and RTU) and Modcomp training courses were attended as well as the DEC GKS graphics course. Membership was held in Modcomp's User Group (MUSE) and annual meetings were attended to stay current with Modcomp's new equipment releases and old equipment support. Battelle in-house software engineering and IBM MVS courses were attended as well as the University of Tennessee Space Institute's aeropropulsion course.

Battelle's CRF on site team provided training for Air Force personnel and other CRF contractors. IBM MVS training, which included an introduction to ISPF, was set up and presented many times throughout this contract. Modcomp training was provided on day-to-day operations, procedures, source editor usage, general usage, and configuration standards. CRF computer system overview presentations were given and day-to-day open shop consultation support was provided for Air Force and other CRF contractor personnel.

Computer Software/Hardware System Configuration

Configuration is a major issue in all computer systems. It is particularly important in an environment such as the CRF, where a network of computers share resources. Battelle performed many tasks to improve CRF/Modcomp configuration.

Battelle established a standard Modcomp Diablo disk structure. The four control computers share resources, communicate with each other via shared memory, and use similar peripheral devices; however, different disk structures were being maintained. This led to the inadvertent deletion and mixing of software and added to the confusion of new and infrequent users. To alleviate these problems, Battelle designed and implemented a common disk structure to be used on all of the control computers. As part of the disk structure definition, control computer software was reviewed and cleaned up, archiving to tape that which was no longer used.

A review and cleanup of all Modcomp computer disks, standardization of naming conventions, as well as elimination of personal user source libraries and software was performed. General user source libraries were created. Backup and restore procedures were generated, including documentation on how to use them. Common source libraries for both the Max III and Max IV systems were created.

Upon completion of the restructure, software trouble logs and log books as well as procedures on how to use them were established to control software changes on all Modcomp systems.

In support of the configuration standardization many Modcomp routines were cleaned up and enhanced. User friendly interfaces were added where appropriate to facilitate the operators' use of the systems. Operator notes were written and modified on the topics of system power up, start-up, power down and backup, as well as specialized procedures. Job control procedures and naming conventions were standardized as much as possible for Max III and Max IV systems. Peripheral devices were standardized and the appropriate software and sysgen changes were made (e.g., the test operators terminal was replaced).

Miscellaneous Support

Control software modifications were made to disregard test termination values other than a normal stop when test article speed was less than five percent.

A market study of protocol converters was performed in anticipation of their use by people outside of the CRF. It was felt that work could be performed more efficiently on a terminal that operated like a Hasp workstation over a dialup line.

Software was written for the DAC computer to diagnose data shifting problems.

Support was provided to General Electric to set up the Simulator computer for light probe testing.

Battelle onsite staff supported instrumentation calibration in the CRF. Calibration software was developed for the inlet discharge and stator vane feedbacks to support work on the servo valve control problems. Online and offline test support was provided for transducer calibration; valve (inlet, discharge, and stator vane/stage bleed) calibration and tuning; and facility, test article and local database modification and generation. This entailed the operation of offline and simulation software as well as the development, modification and execution of new software. Pressure calibration software modifications were made to save PCAL raw data on tape and allow the post-processing software to route the data from tape back to the PCAL software.

The first version of the high speed interactive tape plotting program was written by Battelle on FCC1 using a Tektronix terminal and PLOT10 software.

Security software and procedures were written and reviewed to declassify CRTs, graphic monitors, memory, and disks on the Modcomp computers. The Monitor tape storage software was modified to generate unclassified facility historical tapes during classified testing. Main classification and declassification programs, procedures, and documentation were tested and reviewed for 3277 and 2250 terminals, the 2840 disk controller, and 3330 disk.

Battelle worked with Computer Data Systems Inc. in their development of the CRF security plan. Questions were answered, drawings and listings were generated and documentation was reviewed.

Battelle supported an Air Force effort to evaluate test segments and the ability to choose one of the stator vane stage bleed schedules defined in the Main database. According to Cadre documentation several schedules could be defined in the database and requested when running test segments. Schedules were generated in the database and some preliminary testing was performed.

Event Logging capabilities were enhanced. The Texas Instrument terminal was replaced with a Zenith Z100 computer and a communications package called HyperACCESS was purchased, installed and documented. An internal RAM disk was created on the Z100 computer to allow for buffering of messages.

PLC translation software resides on the Monitor computer and requires input documentation data. Battelle created and documented procedures that would allow the facility engineers to update the file on their Zenith Z100 computer and then transfer it to the IBM. Battelle also wrote procedures to create a Modcomp 800 BPI tape on the IBM for use as input to the PLC translation software on the Monitor.

Monitor software associated with the diesel generator and Building 71B instrumentation monitoring was removed. This hardware is now PLC controlled.

Monitor Magnetic Tape Storage software was modified to add capabilities to set alarm bits to inform test operators through color graphics when tape drives go off line.

Monitor Playback software was modified to allow users to print data from tapes that are not the first in a series. Capabilities were also added to read the facility database from disk if it is unavailable on tape or in memory and to print all 1500 variables if the 'print' option is selected.

The option of replacing the AUX computer with a fiber optic link was discussed. Software and functions which would need to be relocated were discussed, fiber optic vendors were contacted. This task was then assigned to the contractor who provided IBM support. All information was given to them and they generated a report.

The barometric pressure reading was added to the digital data transferred from the DAC to the Main.

Software modifications were made to several of the control computer display software routines. Data was reorganized, removed, and corrected as necessary.

Ten Wanco disk packs were purchased for the CRF Modcomp computers to support software development.

Battelle provided software support for facility modifications to macro/micro sequences. This entailed making changes to the software which controlled the sequences, the actual sequence software and sequence chart software.

DAC global common was decreased in size and software was written in the DAC to resolve a problem related to the reading number being set to zero.

The STEP program was converted into a database, was installed on a Zenith Z100 computer using dBASE II, and was expanded to include functions from a LMCA-developed dBase program. Programs and reports were written as well as data loaded.

Battelle worked with the compressor test group to verify thermocouple correction software, verify static stem and mach number correction software, design a new data engineer database parameter display to provide capabilities to view additional data, and verify calculated data going into PERF.

Scan table setup problems were identified and resolved which accounted for the generator voltage being overwritten in FCC2.

Battelle compared arithmetic calculation speeds of a Modcomp II and a Classic to verify a vendors documentation. The results showed that the Classic performed floating point arithmetic four times faster then a Modcomp II and integer arithmetic three times faster. Air Force personnel selected a version of the control computer Servo software to be used to perform this test. Battelle has built upon this software to develop a benchmark program which is being used as part of the CRF computer replacement study.

Critical Channel Implementation

Critical Channel capabilities were implemented. This included four tasks and incorporated IBM and Modcomp computer support. The four tasks were elimination of PCAL/Channel Check interference, network handshaking, color graphics modifications, and limit check downloading and execution.

PCAL/Channel Check interference refers to PCALs and Channel Checks interfering with the online acquisition, reduction and display of monitor data. PCALs and Channel Checks were previously performed when the CRF was not testing so the inability to acquire, reduce, and display monitor data simultaneously was not a problem. The implementation of critical channels required the ability to recalibrate certain channels while the test was in progress. PCALs take approximately 20 minutes while channel checks take four to five. It was unacceptable to be without monitor data for these lengths of time. To overcome the interference problem Battelle created a new area in global common on the DAC computer for monitor mode formats, allowing for the execution of a PCAL or channel check format and the monitor format simultaneously. Modifications were made to Main run time software to allow it to acquire, reduce, and display monitor data if it was sent from the DAC in between PCAL or channel check data points.

Network handshaking was another task required to support the implementation of critical channels. Network handshaking is performed on the Modcomp computer with CRFNET custom communications software. CRFNET allows messages to be sent from one task to another through the computer architecture. There are also other computer links in the network that do not use the standard CRFNET protocol. The DAC/AUX/Main, TAC1/DAC, and FCC2/Simulator links all have their own special purpose protocols and software.

It is important for the operator and some of the tasks to know the status of the computers and links in the CRF network during facility testing.
The previous network handshaking scheme involved periodic messages from FCC1 to Monitor, and Monitor to DAC only. Other messages, such as Preston status

and DAC/AUX link status, were sent to the Monitor only when a status changed. There were several problems in the design.

- The Monitor computer did not know whether the Main was up.

- If the Monitor was rebooted, it would not know whether the AUX was up because the DAC only sent an AUX status message when the status changed.

- The DAC did not know whether the AUX was up unless it was currently in acquisition mode.

- If the DAC/AUX/Main link went down, it was not easy to determine which link or computer was down.

- The only way to tell whether the TAC1/DAC link was working was to see if acquired data was changing.

- On several occasions, problems were experienced while initializing the DAC and Monitor because of two special messages that were sent from DAC to Monitor and Monitor to DAC. It is possible for the receiver of a message to get the message correctly while the sender detects an error. (The final ACK has an error seen only by one side). It was discovered that the DAC sent an initialization message which the Monitor received, but since the DAC detected an error, it kept retrying. Meanwhile, the Monitor no longer had a receive queued, and it was trying to send a message to the DAC.

- If the Monitor was rebooted while the DAC was taking data, the lights at the data engineers station would not indicate what formats were selected and running.

The new scheme developed by Battelle incorporated the following changes:

- Deleted initialization messages between DAC and Monitor.

- Generated a message from DAC to Monitor every 5 seconds containing:
  - -- Running format number,
  - -- Selected formats,
  - -- Selected transient time,
  - -- Current mode lights, and
  - -- Status of Preston, TAC1 link, and DAC/AUX/Main link.

- Generated a message from AUX to DAC every 7 seconds (if not acquiring data) containing status of Main.

- Generated a message from AUX to Main every 7 seconds (if not acquiring data) containing status of DAC.

- Generated a message from Main to Monitor every 10 seconds containing status of DAC and AUX.

- Retained FCC1 to Monitor handshaking.

- Modified color graphics display number 2 to show status of links as well as status of computers.

One problem encountered using the new scheme was that whenever the AUX had a WRITE queued to the Main and the Main did not have a READ queued (because the real time software was not running), the Main spent 50 percent of its CPU time servicing interrupts from the AUX. (The AUX is also very busy servicing interrupts from the Main.) To alleviate this problem, the AUX now terminates its WRITE after 12 seconds and never tries again until the data engineer requests a reading.

The Monitor color graphics task required that the display of critical channels be redesigned and modified to incorporate the new channels. Color graphics displays related to computer communications were enhanced and modified to include the additional data now available from the new network handshaking scheme.

Critical channel limit checking was the fourth task. Critical channel limits are input into the Main database as engineering units values. They are then converted to counts by using the scale factors stored in the Main database before being downloaded to FCC1. The actual limit checking of the critical channels is performed by the FCC1 computer. Problems were encountered in the engineering units to counts conversion being performed on the Main. This portion of the task was being performed by Air Force personnel.

Some of the critical channels are thermocouples which measure a temperature difference rather than an absolute temperature. This means that the alarm limits in terms of counts may need to change during the day as the reference temperature changes. Battelle developed software that would allow the data operator to have the limits recalculated and downloaded whenever the data engineer judges that the reference temperature has changed significantly.

Battelle enhanced the logic that downloads the test article and critical channel limit check databases. A download is requested by FCC1 when the Monitor computer notifies it. Downloads are requested when panel 2 is armed in Facility mode or when the test operator enters a CCD command. If an error is encountered FCC1 will request it again. A time out option is exercised if the Main doesn't respond within a user defined amount of time.

Facility Historical Data Storage

Monitor facility historical data storage software was restructured for the following reasons:

- It was aborting and a dump analysis showed that a region of memory (about 300 contiguous words) was getting set to zero, with no clue as to where the problem was.

- Whenever the task aborted, a very complicated procedure had to be performed to restart it.

- On initialization, the initialize magnetic tape command was frequently forgotten, with the consequence that the task tried to read to the end of an uninitialized tape and got parity errors. The only way to recover was to manually abort the task.

- Data was being lost while switching tapes.

- A possible tape stall after every write was not checked.

- The logic was difficult to understand because the task was a single module and was not well structured.

The task was divided into 4 modules. The initialization task was modified to no longer require initialization of a tape. The only time the operator might not want to initialize a tape would be if the computer had halted during a compressor test, leaving the tape not closed. To handle this rare event, commands were added in the initialization task to close and dismount a tape, while automatically initialize the first tape as soon as it started.

The problem of losing data between tapes was caused by the fact that Modcomp does not provide for a program to know when a tape has finished rewinding. The standard rewind subroutine returns immediately with the user file table busy bit reset. In order to cope with this, the software was modified to issue a rewind, then immediately follow it with a write of the new directory, and set up the tape stall alarm to occur if the write does not complete within the time it takes to do a rewind.

Monitor Color Graphics Support

One of the primary Monitor computer functions is to provide test personnel with real time information on the facility and the test article. The color graphics system is the primary vehicle for providing an adequate amount of data in a timely, reliable manner. At the CRF this is accomplished with a hardware system consisting of two Ramtek graphics controllers, with four color monitors each, connected to the Monitor computer system.

The supporting software of the color graphics system is based on a unique processor written for the CRF called the Command String Processor (CSP). The purpose of this package was to create an easily used interface to the Ramtek graphics instructions. Other software routines and procedures assist in the testing of the display software, loading and storing of data files, and general use of the system.

Each display screen in the CRF is divided into a background and a real time portion. This allows the background to remain on the screen after being placed there when the display is first selected. Each update, then, requires writing only the changing data, thereby reducing the amount of the screen that must be written with each update. This background task is stored on the Monitor computer disk as compiled Ramtek code, which only requires downloading to the Ramtek controllers.

Most of the software for the graphics displays is written in a high level language consisting predominantly of FORTRAN with "macro" calls that are translated to standard FORTRAN. Some of the background tasks, however, are stored as data files in an established format. These files are used as input to other routines, which allow the designer to easily view the display as it is changed. The online graphics task performs the following functions:

- Check the display selection for each screen,

- Maintain the "annunciator" portion of the screen that flags alarms and warnings in the various displays,

- Activate the downloading of the background portions of the selected displays to the Ramtek,

- Load and activates the dynamic portion of the display.

When a display screen is selected, the background portion of the display is downloaded to the proper Ramtek controller and displayed on the color monitor. The task that constructs the dynamic portions of the display is brought into the Monitor computer's memory. The necessary calculations to display the data are made, and it is then passed along with display information to the Ramtek controllers. When a display is no longer selected for a screen, the display's task is removed from memory.

Battelle has enhanced the color graphics package in the following ways:

- Converted the software and redesigned it to eliminate the overlay structure which is not supported under the Max IV operating system.

- Made the refresh tasks resident in memory to increase the speed and decrease the number of disk accesses.

- Purchased new Ramtek units to speed up the present graphics rate and allow for the use of additional monitors.

- A great deal of display work was done, both in the addition of new and the modification of existing displays.

- Helped to establish a generic compressor map for Monitor display.

- Made extensive modifications to the annunciator program to reduce the number of checks required to find a fault in a display and eliminated multiple bit checks. Also, established a table check for bits reset.

- Improved and expanded the Interactive Graphics Processor (IGP). Replaced use of Modcomp front panel switches with commands. New commands were added to shift and duplicate portions of displays. Commands to clear and preset displays were enhanced.

- Worked with facility personnel to enhance efficiency of displays.

- Worked with facility personnel toward establishing standards for representing data.

Classified Data Tracking

The classified tracking task deals with the way in which printouts, displays, and graphics are defined and labeled as to their appropriate classification. The present system results in some printouts and displays being generated which have classified labels, but in fact are not classified.

Battelle compiled and documented the requirements to provide classified data tracking. We then evaluated the options available to meet the requirements, selected the best alternative and documented the actual steps and effort needed to implement it.

Power Monitoring

Electric companies bill large power users (such as Wright-Patterson Air Force Base) not only by energy used, but also by peak power demand averaged over 30-minute intervals. The electric company must maintain the capacity to supply peak demand even though it usually goes untapped. It is, therefore, very expensive to set a new peak. The power monitoring system provides a method of early warning that a peak is about to occur and displays either, "reduce power immediately to <a calculated value> "or" run at current power for <a calculated time> before dropping to minimum speed for the rest of the 30-minute period.

The power for the base is monitored by a computer which sends information over modems to several different facilities. The messages are sent every 30 seconds and contain the amount of energy used since the last message, the time remaining in this 30-minute period, and an estimate of the total energy that will be used in this 30-minute period.

The computer system was in place prior to the start of this contract; however, it did not completely serve all the CRF's needs.

To adequately monitor, predict, and document power usage, Battelle designed and implemented a power monitoring package consisting of:

- A program that read the modem data and checked it for errors.

- A program that calculated:

    - the CRF component of base power usage (from once/second data collected by FCC1),

    - the background power usage (power consumed by all other users) averaged over the last 4 minutes,

- the time remaining in which the CRF could continue to run at present power before dropping to minimum speed in order to avoid a peak, and

- the power the CRF would have to use in order to maintain constant power and still avoid a peak.

- A graphics program to show total base and CRF energy usage as a function of time over the current 30-minute period. If we were in danger of setting a peak, an annunciator alarm would appear on every graphics screen, and the power display picture could be called up quickly to indicate how long the CRF could continue running or to what level the speed should drop.

The existing facility historical data tape storage and playback system allowed post test analysis in the event of a peak to see whether it was caused by the CRF.

Data Analysis Graphics

Battelle compiled and documented the requirements and options for the implementation of compressor graphics. Input data would come from the Main reduction software.

Battelle consulted with Air Force staff members who would be potential users of the graphics system, and has generated a set of requirements for the graphics system. The requirements document the type of data that should be available to the graphics system, the types of displays the system should be capable of generating, and how the user will interact with the software. The capabilities of the software were divided into what will be needed in an initial system, and what the future enhancements to the system should be.

Battelle evaluated four options for this system which would provide users with the capability to graphically display data from the Main computer's reduction software. The four options included (1) using Tektronix terminals connected directly to the Main and the IBM graphics package DISSPLA, (2) downloading the data to the Zenith 248 computer and using it as a graphics workstation, (3) downloading data to a DEC workstation and using it as a graphics workstation, (4) downloading the data to a Masscomp micro computer and using it as a graphics workstation. Battelle wrote a report evaluating these four options and documented the DEC workstation as the best alternative.

Battelle documented the new software, and changes to the existing software which would be necessary to implement a graphics system. Time estimates in man hours were given to complete the software on the Main computer, and on the graphics workstation.

Battelle developed test software to determine the feasibility of using the Zenith 248 and the DEC workstation as a graphics work station. The majority of the software created by Battelle in this effort will be used in the final configuration of the graphics system.

Digital Control Team

Three Battelle onsite team members were assigned to a digital control team to address problems which could potentially interfere with the successful execution of F100 testing.

Test article speed problems were diagnosed, documented in incident reports, and resolved. Training was provided to Air Force personnel, and trouble logs were resolved. The Battelle members also participated in an extensive evaluation of the Variable Position Control.

Variable Position Control

The CRF variable position control problems included the following:

- One inlet valve was oscillating forcefully against the stop,
- Another inlet valve was opening when it should have closed,
- The discharge valve was opening too quickly and hitting the stop,
- The stator vanes were not following setpoint closely enough, and control was jerky,
- Multiple feedbacks on a single stator vane were showing differences as large as eight degrees.

An extensive review of the software revealed numerous errors: bad analog output addresses and values, wrong variable names, incorrectly dimensioned arrays, irrelevant code, and bad global common addresses. The team also found that the tuning constants for the modified PID control loop algorithm were not properly documented. Battelle analyzed the code in order to document the constants, make sure the algorithm was correct, and tuned the control loops.

In order to ascertain why the stator vane feedbacks were so far apart, Battelle supported the removal of the potentiometers to test for linearity and discovered that several of the pots had loose connections internally. The feedback voltage showed spikes as the pots were rotated. After fixing the software, replacing and recalibrating the pots, and returning the control loops, the inlet guide vane (IGV) feedbacks were still far apart. When moving the IGV from a stop, one feedback would start moving immediately, but the other two would not change until the first had moved several degrees. An inspection showed that the coupling had been damaged due to incorrect placement of one of the stops. Since fixing the coupling would have required an intolerable amount of time, temporary changes were made to the software to control the IGV using only the good feedback, while still displaying the other two feedbacks for operator information only.

It was necessary to calibrate the IGV feedbacks using a nonstandard procedure.

Instead of moving the IGV from stop to stop and letting the computer calculate the calibration coefficients, resistance-versus-angle measurements were used. These measurements had been taken while checking linearity, along with the voltage measured at one stop, to calculate the coefficients manually.

Other software changes were made to ensure that the IGV went to a safe stop at the beginning and end of a test. These modifications allowed successful testing of the F100 compressor unit.

PLC Data Highway

The Operations Group purchased an Allen-Bradley PLC-2/30 to replace the old PLC #2 (in the pit), so that more functions could be added, logic simplified, and trouble-shooting made easier. The following problems were identified at the start of the task:

- The PLC-2/30 required a different communications protocol.

- FCC1 didn't contain enough memory to support both protocols at once.

- FCC1 wouldn't be able to write to the same PLC addresses as before, because all the PLC "input" words are zeroed out at the beginning of each cycle. FCC1 would now have to write to PLC "output" words.

- Addresses 000-007 and 100-107 (octal) are reserved for system use on the new PLC, instead of being used for Rack 0 outputs and inputs. Any references to those addresses in the ladder logic, the control computers, and the Monitor color graphics programs would have to be changed.

In order that only one protocol would have to be supported, the Air Force purchased a data highway interface for the old PLC which would allow it to use the new protocol. This required different interfaces for the new PLC and FCC1. However, using a data highway has some advantages:

- The PLCs can send data directly to each other, instead of relaying it through FCC1.

- It is possible to add an intelligent terminal in the control room for trouble shooting.

The following work has been completed except for final online testing, the backup/restore function, and documentation.

- Both PLCs were connected to the data highway, logic was added to send a word from PLC-2 to PLC-1 which was previously relayed through FCC1 and software was written in FCC1 to communicate with the data highway, without changing any PLC addresses.

Several problems were encountered and overcome in rewriting the communications software:

- It was discovered that the old software would hang up if no reply was received from a PLC, or even if the reply was one byte short. If just one of the two PLCs had a problem, communication with both PLCs (and with the Monitor) would cease. This problem was easily fixed by implementing a timeout of 0.4 seconds between sending a command and receiving a complete reply. (The maximum time ever observed for a good reply was 0.22 seconds, but this may increase if another device is added to the data highway.)

- It is impossible under the new protocol to know in advance how many bytes will be in a reply. This is because any data link escape in the data gets expanded into two. An input buffer of over 1000 bytes was used and is being used today instead of one half that size. More importantly, this created the next problem.

- Since there was no special character (such as a carriage return) to indicate the end of a message, a binary read was used which would not complete until an exact number of characters were received. The first scheme involved queuing up two reads so that the second buffer automatically took over when the first was full, allowing a single message to span both buffers. Unfortunately, it was discovered that the hardware created noise at the start of a new buffer.

- There is a known problem in Classics running MAX IV rev F, using models 4804 and 4806 RS232 controllers, which may cause a computer to halt if uncompleted reads are terminated. Upon receipt of the "abort terminate" command, the hardware generates an unexpected interrupt which the software doesn't properly handle. Battelle's first scheme described above was designed to avoid this problem, even though it was not known whether it would occur on a MAX III Modcomp II with a model 4811 RS232 controller. Since it did not work, the software was changed to issue a terminate after each command/reply cycle. Battelle ran this configuration for several hours to see whether the system would halt. It did not. However, this test will have to be repeated when the control computers are replaced with Classics running Max IV. If the computer does halt, two options exist. Going to rev I, or modifying the handler so that an input buffer is used as a circular buffer and is never released.

- To speed up communications, and make the two reads from a single PLC be close together in time, four read commands were issued at once before waiting for the reply to the first command. However, the data highway was unreliable under these conditions: 12 errors occurred out of every 1000 one-second cycles. Consultation with Allen-Bradley revealed that the box being used had some noise problems and they replaced it with a later series box which reduced the error rate to about 4 errors per 1000 one-second cycles.

- Logic was added to the PLC communication subroutine to E-trip if 10 consecutive one-second cycles had any PLC errors in either reads or writes.

- The main program in FCC1 was changed to E-trip if the one second task took more than 3 seconds to do its "one-second" work. (It previously tripped, if it took 1.5 seconds.)

- There are two ways to send data to a PLC: "word" writes and "bit" writes. Word writes can write to several addresses with one command, but only if the addresses are consecutive. Bit writes can write to scattered addresses with a single command, but are slightly less efficient if only one word needs to be written. The PLC communication subroutine was changed to use bit writes instead of word writes, making it faster if multiple words need to be written.

It takes about 0.74 seconds to read all the data from both PLCs. If all nine words need to be written, then it takes a total of 1.09 seconds to do the I/O (not counting limit checking and sending the data to the Monitor).

The following tasks remain to be accomplished to complete the implementation of the new PLC configuration.

- Reconfigure the I/O racks, the ladder logic, and the Modcomp software so the old PLC uses the same addresses as the new PLC. This allows the CRF to fall back to the old PLC simply by moving the I/O racks without moving any individual I/O cards.

- Write the ladder logic for the new PLC.

- Replace the old PLC with the new one.

- Purchase software to display, modify, and print ladder logic. (The Modcomp software that is currently used to print ladder diagrams would have to be modified extensively to work with the new PLC, and it would not be cost and time effective.)

Configuration Codes

IBM and Modcomp software modifications were made to enhance the implementation of configuration codes. Test Article speeds which are calculated in the TAC computer are sent to the DAC as digital data. The distortion screen, build number and test segment related configuration codes are entered from the Monitor test operator's station and sent to the DAC. The DAC sends the entire set of codes to the Main computer where they are incorporated in the tape directory.

Transient Data Acquisition

Transient data is data taken from the compressor while some aspect of its performance is changing. A paper was written by Air Force personnel on transient data acquisition. This capability was part of the original design of the CRF but was never totally implemented by Cadre. Problems which Battelle resolved were:

- The DAC was running an operating system which limited it to 64k words of memory. This meant that the DAC could not buffer scans, but had to send them one at a time to the AUX, which reblocked them before relaying them to the Main. If the system had worked, it would have been much slower than the present package, because of this DAC/AUX link bottleneck.

- The AUX software was written in such a way that it needed to know the size of buffers before they were sent, so that it could queue up multiple READS using consecutive blocks of memory. This involved some extra handshaking, which did not work very well due to poor error recovery logic, and because, when the buffer size changed, all the READS to the link had to be terminated, which frequently caused errors on the other side.

- An end-of-reading flag was supposed to be set in the last scan as a signal to the AUX to terminate the unused reads and start a new sequence. If an error occurred on the last scan, however, both the AUX and the Main would lock up.

- Even if the end-of-reading flag made it safely to the Main, it was missed because the Main was looking for it in the first scan of each buffer instead of the last.

- Major portions of the code in both the Main and the AUX were written in assembly language and were extremely complicated. For example, one huge program in the Main handled both Monitor and AUX links, although the protocols and the uses of the data were quite different.

To fix these problems and get the transient data system running in its present efficient and reliable manner, Battelle performed the following:

- Upgraded the DAC operating system from Max III to Max IV.

- Rewrote most of the data collection and transmission program in the DAC so that it filled up a 32k byte buffer before sending it to the AUX.

- Eliminated the DAC/AUX buffer size handshaking. The AUX now queues up two 32k byte READS and determines how many bytes it received after a READ completes.

- Rewrote the Main software that controlled the Monitor and AUX links to create separate small assembly language modules to send the channel commands to the links, and FORTRAN programs to handle Monitor link messages, data acquisition buffer handling, and tape storage.

Once the transient data software system was verified to be working as required, the hardware was evaluated further.

Battelle wrote several offline diagnostics to be run every morning before a compressor test. The first diagnostic required making up a special patch panel to patch a single voltage source (which was a sine wave) into all the channels simultaneously. For each channel, the program reads that channel and another channel, first consecutively, then separated by ten other channels. It does this 100 times and calculates the average absolute difference between the two channels each way. If the "hold" feature is operating properly, the average differences will be about the same. Otherwise, the difference between the two channels read ten channels apart will be much greater than when read consecutively.

Other diagnostics were written to test the relative calibrations between the two amplifiers on each card and to test the "droop" rate.

The sample and hold diagnostics immediately proved their worth by showing that approximately half of the cards had failed in some way. The new software was also essential to the effort in calibrating the amplifiers.

To support the Transient Data Acquisition task defined in Task K, several software modifications were required on the Modcomp computers. These modifications included:

- Writing software to determine the speeds attainable for the Main link, the serial link, and the Preston with various buffer sizes.

- Many changes were made to DAC software to speed up statics and transients.

- AUX software was rewritten to interface and work with the new DAC software.

- The Main buffering scheme was modified and streamlined to achieve a rate of four megabytes/second.

Stator Vane/Stage Bleed Expansion

The stator vane/stage bleed expansion project was started by the Air Force. Battelle then supported their effort by participating in the design review. Support was provided to make the necessary database modifications, recreate and enlarge the direct access files required, and participate in testing and resolution of hardware problems.

Global Common Database

Battelle designed and partially implemented the Global Common (GCOM) Database to assist in Modcomp software design, development, and documentation.

Tasks within the CRF computers communicate with each other by sharing global regions and, if in separate computers, through a communication task. Shared global commons are used by both of these means.

In the current environment, standards have not been established as to the use and definition of these areas. GCOM will help a programmer identify and understand the interrelationships and/or interdependencies between routines using a global shared region. It will also aid in the development of standards for global common use. It will assist Modcomp programmers in all facets of software development by allowing them to search for and list data based on various parameters as well as update and print database reports.

Battelle defined the requirements, designed, implemented, and documented the GCOM database system. Its development was based on the use of the Enable database software.

Modcomp Operating System Upgrades

Modcomp operating system upgrades from Max III to Max IV were performed on the DAC and Monitor computers. All custom device handlers were modified as well as the communications software. Software bugs found in the Modcomp terminal handler, the interrupt logic, and the abort logic were resolved. Disk drives were restructured and all handlers and interrupt routines were modified to interface with the new file structures. Max III operating system modifications were eliminated.

Disk drive problems were encountered with the Monitor computer as part of the upgrade. Further investigation isolated the problem to the disk drives handling of load modules which span track boundaries. The Max III operating system performs reads as sector-to-sector transfers, Max IV reads by DMP chaining. The disk drive was also found to be incompatible with other disk drives in the CRF and laboratory; it was temporarily replaced with a borrowed disk drive.

Tasks that were originally set up as overlays were restructured because Max IV doesn't support overlays.

Communication software was converted to Max IV and problems were resolved as they were found and identified. Many idiosyncrasies in Max III became major problems with the installation of Max IV. Battelle modified DAC/AUX protocol to allow the link to recover from errors. Software was written for the Monitor and AUX to keep Main links from timing out. Data buffer sizes were increased in the DAC to decrease the frequency of DAC/AUX link errors.

Analog Tape Digitizing System (ATDS)

Air Force security regulations were reviewed with respect to their implementation on the ATDS, a Masscomp computer. Passwords were set up for the system and single user accounts. System file permissions were reviewed. Files related to the use of 6250 BPI tapes for backups were recovered and backup procedures were generated and documented.

Laser Transit Anemometer (LTA) / Laser Doppler Velocimeter (LDV)

Battelle provided hardware and software maintenance and upgrade support for the DEC LTA and LDV systems.

Requirements

- Increase the RS232 communication from four to six ports to include the traverse table operation.

- Convert either the LTA software in RT11 version 4.0 or the Traverse Table software in RT11 version 5.0 to a common version of software so both sets of programs can operate at one time.

- Modify the LTA software so it can access the Traverse Table software from "front page" commands.

- Modify the LTA software to write the reduced values of velocity and turbulence level to the LTA file so they can be printed.

- Modify the LTA software to read an LTA file and redisplay the data.

- Develop a print/plotter output capability of the LTA or Traverse Table displays.

- Support the investigation and resolution of electronic problems that arise in the LTA system.

- Purchase windows to transmit laser light.

- Establish a working LDV MicroVax computer system with needed user accounts.

- Install NASA LDV software on LDV MicroVax.

- Implement LDV computer control of TSI Frequency Shifters.

- Implement LDV computer control of Traverse Table, transferring control code from PDP-11 if possible.

- Incorporate Frequency Shifter and Traverse Table control into NASA LDV software.

- Install NASA LTA software on LDV MicroVax.

- Provide general LDV MicroVax system support.

- Establish security procedures for LDV CRF classified operations.

Battelle Actions and Results

Battelle performed the following tasks to resolve problems and enhance the LTA and LDV systems.

An eight channel serial line interface was purchased and installed which increased the number or RS232 communication ports from four to six. This interface also allowed for traverse table operation as part of the LTA system or a stand alone job.

The LTA and the Traverse Table (TRV) software were supported under different versions of the DEC RT11 operating system. The LTA software executed under DEC RT11 Version 4.0, and the TRV software executed under DEC RT11 Version 5.0. Battelle converted the LTA software to run under DEC RT11 Version 5.1 XM Monitor and linked it to the virtual overlays to speed up software execution.

Read/Write capabilities for the eight-inch floppy disk drive were not initially available; however, patches were obtained and installed. The TRV software was brought up to execute under the same Monitor to allow switching between systems without rebooting.

A study was performed to analyze whether the LTA software could be modified to access the Traverse Table software from front page commands. Many problems associated with integrating TRV functionality into the LTA software were identified. The two most significant problems were:

- LTA software was written in Pascal while TRV software was written in FORTRAN and Macro-11. Multiple languages would significantly compound the integration effort.

- Tests were performed to interface the software with the required external devices. It was found that the Traverse Table position cannot be recorded on the "front page" or "panel" because it attempts to move the table and will ultimately stall the software.

Final results indicated that commanding and reading the SONY DRO unit from the LTA software was possible. However, commanding the Modulynx unit to move the table is neither a simple nor straight forward task. Minor integration of the two software systems was performed. The issue of a major rewrite was postponed.

Modifications were made to LTA software to write the reduced values of velocity and turbulence level to the LTA file to be printed. It was discovered that if a data file was reviewed online during LTA testing the values of velocity and turbulence level were stored in the LTA file. However, if the online review is not performed, the velocity and turbulence level were not calculated and consequently not stored in the data file. An acceptable solution was implemented to calculate the velocity and turbulence level for each data point as it is taken and stored on the LTA file, independent of whether an online review was done.

Software modifications were made so an LTA data file could be read into a post-processing program. This functionality was not considered in the initial design of the software and will require additional Air Force in-house review to resolve the discrepancy between post-processed and online data. Battelle was also asked to read the data back into the online software routines so the graphs could be reproduced. The post-processing routine uses FORTRAN and the Air Force needs to obtain the license and manuals for the FORTRAN compiler for the DEC equipment.

A printer handler for the Decwriter II was purchased and installed.

Alternative approaches for implementation of modifications to the LTA and TRV were addressed in September 1985, and January 1986, memos to the Air Force. Battelle obtained quotations from manufacturers related to the custom development of five windows to transmit laser light. The window specifications were generated by the Air Force, and, upon their selection of a manufacturer, the windows were purchased by Battelle.

The Air Force then purchased an LDV MicroVax computer system. The Vax VMS operating system was installed, and user accounts established. The system account was protected, and standard 'default' accounts were disabled. The printer was configured and the necessary queue established on the system. Captive accounts and procedures were developed to allow both shutdown of the system, and backup of the total system's software by non-privileged users, without full access to system privileges. This removes the need for a constant system operator, without exposing the system to well-meaning, but unknowledgeable users with system privileges.

Support was provided to NASA personnel during the initial installation of the NASA LDV software in a temporary directory. After NASA's initial installation and testing, the software was moved to its own account directories. Directory references within the code were modified for the LDV MicroVax environment.

The proper cabling for the TSI Frequency Shifter control was determined in conjunction with Air Force personnel. Software interface routines were then created to allow control, including status checking, of the frequency shifters. A crude, but effective driver was written to allow direct computer control of the shifters by the user. A minor hardware modification was made to the TSI Frequency Shifters to allow Local/Remote operation status to be read by the interface software. The status checking routines of the software interface were modified to incorporate this change.

At the onset of this task, it was hoped that the control software for the Traverse Table could be transferred with little modification from the PDP-11 LTA computer. After sorting through all the available pieces of the software, it was determined that a lot of it was not actually used and most of the PDP-11 software was written in PDP-11 MACRO language. It was then decided that it would be more efficient to totally rewrite the Traverse Table software for the MicroVax. Since a total rewrite was necessary, the decision was made to use the power of the MicroVax VMS operating system routines to write the interfaces in the higher level language FORTRAN. This would allow easier conversion for operating system or computer upgrades, and if rewrite was necessary, an easier understanding of the algorithms for the programmer. A complete set of control routines and documentation provide a simple interface for Traverse Table control to the user's code. Work was slowed on this task by the lack of documentation on the Modulynx controller interface, and the apparent discrepancies between the documentation and the observed function of the equipment. A crude, but functional interface driver was written to allow direct computer control of the Traverse Table by the user.

A separate program was written to use the Traverse table interface to seek an 'absolute' origin provided by the Traverse Table Position Indicator hardware. Testing of the repeatability of locating this origin yielded even better results than anticipated. The accuracy and repeatability of table movement was tested in the mid-axes range with excellent results. Testing at the extremes of the axes was impractical due to the difficulty of mounting measurement standards and micrometer dial indicators, but some preliminary tests alluded to results equalling those in the mid-axes range.

A new 'working' version of the NASA LDV 'tsi_acquire' data acquisition software was created to incorporate the CRF Traverse Table and Frequency Shifter control interfaces. This also included the slight modification of several other program features to better fit into the CRF environment. Procedures used to compile and link the software were modified to incorporate the interface code.

The NASA LTA software has been 'installed' in its own account directories. Explicit directory references throughout the code were modified to reflect local system directory configuration. The software was reviewed with compressor test group members.

Battelle has functioned as an 'open shop' to users of the LDV MicroVax system, with training and assistance provided to users on an informal basis at both, the system and programmer levels. Technical support was provided concerning future system configuration and expansion needs.

Specific problems on the MicroVax system, such as, sporadic write-lock errors on the system disk drive, were investigated by Battelle. In this case, the EMULEX controller diagnostics were procured from Cambridge Automation, and the disk tested. This included over 18 hours of disk verification; writing, reading, and comparing, sixteen different bit-patterns to every sector of the disk at least twice. This process did not reveal a single error. DEC service personnel were unable to diagnose the problem due to its sporadic nature.

EMULEX was called directly for ideas on how to isolate the problem. No similar problems with the revision of the controller board on the LDV MicroVax system had been encountered. An upgrade kit to bring the controller board up to the latest revision was obtained by the Air Force and no further disk write-lock errors have been experienced.

The development of security procedures for CRF classified operations encompasses a wide variety of tasks, and has taken a number of approaches. The original thrust included the use of the existing disk drives on the system. This constraint brought on a number of problems because all disks used during classified processing must be totally overwritten with several bit-patterns. Toward this end, the second disk drive on the system was split into two 'logical' drives. This was done by reprogramming the controller board, making the operating system believe it has three disks attached to it. This was not done to increase the number of drives on the system, but to decrease the size of the disk used during CRF classified operations. The logical drive was sized to provide the needed space during a run, but minimize the time needed to 'clear' the disk afterwards. A method was developed for use in the classified 'shutdown' to insure that only the proper disk was used during the CRF run. Any other disks used would tremendously increase the declassification time, and would probably result in lost software/data.

A completely separate software system was constructed for CRF classified operation, with only the LDV and LTA user accounts. This was to help decrease the needed disk size and to help prevent usage of unauthorized disk drives. The system is kept on tape like a normal full-system backup, and is, itself, unclassified. Any data collected during CRF runs would be transferred to a classified tape. The system is not saved at the end of a run, but rebuilt from the same tape for each run. This, not only allows the system tape to remain unclassified, but allows the system to be installed on the disk previous to creating a classified environment. Procedures have been written to save the data files to tape, to backup the system if software is changed, and to build the system on disk. At this point several problems became apparent. The time required to save the collected data to tape, clear the disks, and rebuild the operating system for the next day, was estimated to be over two hours. This amount of time after each days operation seems unacceptable. It was also discovered that the MicroVMS operating system did not allow writing physical blocks to disks, as the VMS operating system did. At this time, we had no manuals beyond the very basic users' set. This ability was necessary to insure that each and every sector of the disk was written over by the required security bit patterns. The only other way to insure this, was to write the task at the 'device driver' level, a long and difficult process, or to train all personnel to run the field service diagnostics. Either option is both risky and time consuming.

Battelle proposed the purchase of a removable Winchester disk subsystem which is the safest, most cost effective, as well as the classical approach to disk security in classified operations.

These Winchester style drives can replace the existing drives giving a comparable capacity (760 Mbytes) in a removable configuration. Since the whole drive is removed as a unit, the drives do not suffer from the usual loss of capacity and transfer rate seen in removable-pack drives.

It was proposed that two 'drives', one for normal and one for classified running, be purchased. At the end of a day's run the classified disk would be removed and locked in a safe, eliminating the time needed to clear the disk and rebuild the operating system. This should reduce the declassification time to under a half-hour. When not in a classified test run, the second drive would be used for system operation. If a drive should somehow be destroyed, there would still be a drive that could be 'classified' and used to minimize down-time during a run.

A number of vendors were queried as to available systems and our findings were given to the Air Force.

A method to over-write physical memory with security bit patterns is being researched for the LDV MicroVax.

Test Support (4.1.2)

REQUIREMENTS

This task shall require the contractor personnel to assist the Air Force during R&D testing in order to acquaint them with the system, to demonstrate problems to them, and in many cases for them to check out, debug or tune their modifications online. This shall occasionally require up to 12-hour workdays at short notice and/or second or third shift operation.

BATTELLE ACTIONS AND RESULTS

CRF minimum manning support was provided for the positions of IBM and Data Operator as well as for Modcomp first floor signal conditioning room. Support was provided for High Tip Speed I, Fan Durability, Laser Transit Anemometer, F100,and GE Swept Rotor compressor classified and unclassified testing.

Noload, 12.4, Frequency converter and Auxillary test runs were supported. Frequency converter maintenance procedures were supported to "sync in" the frequency converter.

Pretest and post test support was also provided.

Procurement and Installation of Drive System Hardware and Required Equipment as Defined in Task I (4.1.3)

REQUIREMENTS

The contractor shall procure and install all hardware and equipment that the contractor defines in 4.4.6.5.

BATTELLE ACTIONS AND RESULTS

Due to the limited funding of Task I, this subtask was not completed as requested by the Air Force.

Development of an Acceptance Test Procedure and Performance of the Agreed Upon Acceptance Test of the Drive System Developed in Task I (4.1.4)

REQUIREMENTS

The contractor shall develop an Acceptance Test Procedure (ATP) to thoroughly test the control system developed in 4.4.6.3 to demonstrate the new control system using all hardware and equipment which has been procured and installed in 4.1.3. After Air Force approval of the ATP, the contractor shall perform this ATP and debug the control system, hardware, and equipment until the ATP runs successfully. The contractor shall demonstrate to the Air Force successful execution of this ATP.

BATTELLE ACTIONS AND RESULTS

Due to the limited funding of Task I, this subtask was not completed as requested by the Air Force.

Analog Tape Digitizing (4.1.5)

REQUIREMENTS

The contractor shall develop an integrated tape digitizing system that will:

- Digitize up to 32 analog channels from magnetic tape at a sustained aggregate rate of up to 400 KHz.

- Allow operator control of the tape speed and direct, drive selection, IRIG code, and filter types of the analog tape recorders.

- Control tape and data acquisition based on a decoded IRIG time.

- Control system calibration.

- Manage data files and output data onto digital tapes in a format that is compatible with the CRF Main computer's 6250 BPI tape drives and with the CRF's Interactive Signal Analysis Package.

- Format the output data tapes in accordance with the existing CRF Standard Format Tape Specifications. Any deviations from the CRF Standard Format Tape Specifications shall be coordinated in advance with the Air Force.

- Allow for storage of system setup states.

The contractor shall provide to the Air Force all manuals and documentation provided by vendors and shall document any modifications or additions to software and hardware described in these documents.

BATTELLE ACTIONS AND RESULTS

Battelle defined and evaluated three prototype systems to meet the CRF digitizing requirements. Preston and Modcomp systems were evaluated because of their availability in the CRF. A Masscomp system was also evaluated. Based on Battelle's recommendations, regarding the three systems, the Masscomp system was selected. Battelle purchased a Masscomp MCS-5500 computer system and a data acquisition software package called IDARS developed by Creare. Battelle then assembled and integrated the digitizing system for the CRF to be used to digitize and analyze dynamic test data. The components were procured and assembled. The software was installed and the system checked out. Problems were encountered while interfacing the Datachron tape control unit (an existing CRF instrumentation component). The Datachron tape control unit problems were identified to the Air Force and had been previously documented by Creare. It was agreed that Air Force personnel would resolve these problems. SOW item 4.1.5.1.6 could not be completed due to the problems encountered. Funds were expended in an attempt to resolve the problems.

Battelle delivered the system to the Air Force on August 14, 1986. An interim technical report, as well as all manuals and vendor documentation, were delivered to the Air Force in August 1986.

TASK B - SIMULATOR SUPPORT (4.2)

OVERVIEW

The CRF simulator is intended to be used to test software and database modifications and to train facility operators. The simulator requires the normal maintenance that any complex software requires. Although the software that simulates the facility is fairly stable, each new test article that is installed in the CRF requires custom software to match its configuration and performance characteristics. When facility equipment is modified, a corresponding modification must be made to the simulator. Sometimes, a different or more detailed simulation may be required for a piece of equipment. The PLC functions are simulated; so when the PLC relay circuits are modified, a corresponding change is required in the simulators. This task involves work in simulation, real-time programming, custom device handlers, communications and database management. It also involves training Air Force personnel in the operation of the simulator.

REQUIREMENTS

The contractor shall maintain and repair the CRF facility simulator software to keep it operational and current with the CRF configuration. The operation of the simulator requires access to the CRF computers, which depends on the Air Force testing schedule. This shall sometimes require contractor personnel to work second or third shifts. The contractor shall update the Simulator User's Manual as required to keep it current as a result of the contractor's maintenance and repair work.

BATTELLE ACTIONS AND RESULTS

The number of data acquisition channels was updated from 540 to 672 on the Simulator computer.

The first valve tuning software was written for the control computers. Its purpose was to obtain data required to simulate the operation of the valves in the test article control sequence and simulated testing. Capabilities were included to modify acceleration coefficients, scale factors, and position factors associated with Inlet, Discharge, and SV/SB valves.

Flow straightener data was received from the test group and installed.

Critical channel assignments were updated.

Memory space limitations quickly became a problem in the control computers as the symbiont device handlers were installed. To help solve the problem PLC1 and PLC2 Simulation handlers were combined into one, and the wide range handlers on TAC1, TAC2, and FCC2 were made more efficient through the use of the Modcomp Q$UNQ routine.

The main task in the simulator was converted from a onemap to a twomap task to decrease system task switching time and simulation cycle time.

The operating system was upgraded from Rev D to Rev F. Errors were corrected in timing system routines which directly interfaced with the operating system. Facility software has been very volatile over the past three years. The successful use of the Simulator is tightly coupled with the facility software. The volatility of the facility software made it very difficult to keep the Simulator up to date. Documentation procedures were nonexistent at that time and word of mouth was hard to follow.

The simulator became known as a spare parts machine. It was used to swap out and test bad hardware by SRL. This resulted not only in system down time but when the system was once again available it was found that Simulator components had been disconnected and not reinstalled correctly. SRL installed 2 Wanco disk drives on the Simulator to support the GE light probe system. Alignment problems were present with existing and new drives causing many hours of down time.

Contract modification P00009 dated December 19, 1986, eliminated Task B due to the above mentioned problems.

TASK C - COMPLETION OF SIMULATOR (4.3)

OVERVIEW

The CRF simulator requires functions that have not been completely implemented. These functions are described in the simulator documents that were made available by the Air Force.

REQUIREMENTS

- The contractor shall develop a custom Max III compatible device handler in the DAC computer to route analog input data from global common instead of from the actual Preston device. The Preston High Performance Data Acquisition System acquires test article performance data for the DAC computer. This handler shall function similarly to the analog input handlers in the control computers.

- The contractor shall develop a Max III compatible custom handler to the DAC computer to route I/OIS digital I/O and analog outputs through global common, instead of through the I/OIS hardware.

- The simulator operator has the capability to interject failures in the simulated facility. This enables testing of the CRF software limit checking, testing of recovery from abnormal conditions, and training operators. This capability has never been tested. The contractor shall develop an acceptance test procedure (ATP) to thoroughly test this failure interjection capability. After Air Force approval of the ATP, the contractor shall perform this ATP and debug the simulator until the ATP can run successfully. The contractor shall demonstrate to the Air Force successful execution of this ATP.

- The CRF computers run under simulator or real operating systems. To ensure that the computers are all running under their simulator systems or all under their real systems, a microprocessor-based system was designed to communicate with the test operator and with each computer as it starts up and does not allow that computer to run with the wrong operating system. The system has been installed but has not been integrated. The contractor shall integrate the microprocessor system in accordance with the simulator design. The contractor shall develop an ATP to thoroughly test the functions of the microprocessor system. After Air Force approval of the ATP, the contractor shall perform this ATP and debug the microprocessor system (including hardware and software in the microprocessor and in the CRF computers). The contractor shall demonstrate to the Air Force successful execution of this ATP.

BATTELLE ACTIONS AND RESULTS

Battelle accomplished the following work under this task:

- The DAC was updated to include a simulator operating system.
- Communication software was installed in the DAC and tested.
- Microprocessor software was installed in all four control machines and tested.
- A symbiont device handler was written for the Preston HPDAS unit.
- Failure software testing was initiated.

Contract modification P00009 dated December 19, 1986, eliminated Task C.

ENHANCEMENT SUPPORT TO FACILITY AND SIMULATOR ON-LINE SOFTWARE AND HARDWARE (4.4)

During the first year of the contract, Battelle performed a number of tasks in support of the facility and simulator on-line software and hardware. These are described in the subsections that follow.

TASK D - DATA ACQUISITION SYSTEM SUPPORT (4.4.1)

OVERVIEW

The test article data acquisition is controlled by the data engineer via the Monitor and Main computers. Commands are sent from the Main and Monitor computers to the Data Acquisition computer (DAC). The DAC acquires data and sends it through the auxiliary computer (AUX) to the Main computer. "Hang-ups" occur in some situations when one of the four computers gets out of sequence due to timing problems or improper error recovery. These "hang-ups" need to be resolved.

REQUIREMENTS

The contractor shall investigate the data acquisition "hang-up" problems to determine their causes and develop a handshaking protocol that will guide the four computers through the proper sequence to provide graceful error recovery and to provide additional status information to the data engineer.

BATTELLE ACTIONS AND RESULTS

An extensive analysis of the Data Acquisition system was performed by Battelle through our participation in online and offline CRF testing. Software and documentation were reviewed and results were documented in an Interim Technical Report delivered to the Air Force in November, 1987. The recommendations were implemented under Task A, Support to Facilities.

TASK E - MONITOR COMPUTER OPERATING SYSTEM UPGRADE (4.4.2)

OVERVIEW

The Monitor computer required an operating system upgrade from Max III to Max IV. The Max IV OS required more memory than that available on the Monitor computer. There was a need to determine how much memory is required for the upgrade. Numerous modifications had been made to the Max III OS during CRF construction integration. The Monitor had two custom device handlers that were not supported by Max IV. These handlers, which drive the Modcomp to Modcomp serial communications and the Ramtek color graphics, needed significant modification to be compatible with Max IV. There was also a large amount of Assembler language software that required inspection to determine what incompatibility problems need correcting.

REQUIREMENTS

The contractor shall determine what changes have been made to the Max III operating system in the monitor computer, which ones can be accomplished in the applications software, which ones are not necessary, and which of these modifications shall be required to be made to Max IV. The contractor shall determine what changes to make to applications software, job control language procedures, system generation and hardware to make them compatible with Max IV. In addition, the contractor shall investigate modifications that will more fully utilize Max IV features to increase system performance. This task shall require a very good understanding of the Max III and Max IV operating systems.

BATTELLE ACTIONS AND RESULTS

Battelle performed the Monitor operating system upgrade study and submitted an interim technical report in June, 1986. The actual operating system upgrade was performed under Task A Facilities Support.

The study defined the memory requirements which was purchased and installed by the Air Force through Systems Research Laboratory. Hardware revisions at the board level were installed by Modcomp. Operating system modifications, custom device handlers, disk restructuring and software modifications were documented in the study.

TASK F - ON-LINE DIAGNOSTICS (4.4.3)

OVERVIEW

The CRF computer network was designed to detect abnormal conditions in the facility and the test article. If an abnormal condition is detected, the facility operator is warned and the facility test may be terminated in one of several ways, depending on the condition. Much time and effort are often consumed by facility personnel in determining the exact cause of such failures. Better online diagnostics were needed to improve personnel efficiency.

REQUIREMENTS

The contractor shall investigate all causes of CRF abnormal test termination and determine what diagnostics now exist and develop diagnostics in both the PLC software and the Modcomp software to more extensively evaluate the abnormal condition and inform the operator of exactly what condition terminated the test.

BATTELLE ACTIONS AND RESULTS

The Task F online diagnostics study was eliminated from the contract in modification P00009 in December 1986.

TASK G - PLC SIMULATION (4.4.4)

OVERVIEW

The PLCs are represented in the simulator by a simplified model in order to minimize computer time. Changes to the PLC logic require corresponding, but often nontrivial, changes to the simulator. The simulator design did not allow for easy changes because the PLC software was considered fixed. Our experience has shown that PLC changes are made frequently. This task shall develop a method of simulating the PLCs that shall be easier to change.

REQUIREMENTS

The contractor shall study the method used to simulate the PLC software and to develop a simpler procedure for updating the simulator with PLC logic modifications. This may require a change in the simulation method used, but the performance of the simulator must not be reduced.

BATTELLE ACTIONS AND RESULTS

The Task G PLC Simulation study was eliminated from the contract in modification P00009 in December 1986.

TASK H - GRAPHICS RESPONSE TIME (4.4.5)

OVERVIEW

The Monitor computer displays facility data to the test operators using two Ramtek 9100 color graphics generators that drive four CRTs each. The time between updates can be quite long for operators to monitor quickly changing variables. The update time using one CRT is good, but using additional displays degrades the response time. Effective monitoring of the facility requires that update time when multiple CRTs are used be decreased.

REQUIREMENTS

The contractor shall investigate the cause of the long update time in the color graphics system and recommend methods of reducing that time.

BATTELLE ACTIONS AND RESULTS

The Task H graphics response time study was performed in conjunction with several tasks associated with this contract. Graphics response time was an issue addressed in the Monitor operating system upgrade study and the actual upgrade. Throughout this study we worked with facility personnel to streamline display and alarm indicator requirements. An interim technical report was delivered in December 1987.

TASK I - Drive System Control Instability (4.4.6)

OVERVIEW

The frequency converter (FC) is a 44,000 hp machine that is driven by two 5,500 hp DC motors to a speed of 514 rpm, where the FC output is equal to that of the synchronous drive motor, which is being turned at 10 rpm. This is required to synchronize the drive motor with the frequency converter. Once synchronized, the drive motor speed is a function of the FC speed. The problem encountered is that the FC speed becomes unstable when it approaches 500 rpm. This causes excursions of DC motor armature current at 1000 amps/sec, which is intolerable at this high commutator speed. Little control is available to the digital control loop because a small acceleration requires a large armature current at this speed. To get around this problem, the DC motors do "push-ups" (the speed is repeatedly ramped from 100 RPM to 500 RPM and back). For unknown reasons, this reduces the instability enough to synchronize the drive motor. Three digital models of the CRF electrical drive system were made available to the contractor for use in this task. The three models are the Cadre model, the System Control Technology model, and the Air Force Institute of Technology model.

REQUIREMENTS

The contractor shall investigate the instability in the CRF electrical drive speed control system and determine all hardware/software modifications required for a stable system.

4.4.6.1.1 The contractor shall develop a model to predict the performance of the CRF electrical drive system including speed control. The contractor shall review the three existing Air Force digital models, selection and modifying parts of these models as applicable for use in developing a new model.

4.4.6.1.2 Output of the model shall include input and output parameters (volts, watts, vars, torque, angle, speed setpoint, ramp rate, speed, pullout point) for each drive component. The contractor shall design the model to be modular so individual components can be easily removed, added, or interchanged. The input and output parameters shall be limited by the physical limits of the equipment being modeled.

4.4.6.1.3 The contractor shall determine the characteristics and transfer functions of each drive and speed system component. Literature reviews, physical tests, and subcontracts to original manufacturers or consultants may be used for analysis and tests.

4.4.6.2 The contractor shall develop an Acceptance Test Procedure (ATP) to thoroughly test the model which was developed in 4.4.6.1. The ATP shall demonstrate the accuracy of the digital model by comparing its predicted output with the measured response of the electrical drive system. The results of the comparison shall be accurate within +10 percent of each model output parameter. A comparison shall be made for both steady-state and transient conditions for each model output parameter. If accuracies within the specified range are not obtainable, the contractor shall provide a detailed explanation for the inaccuracies. After Air Force approval of this ATP, the contractor shall perform this ATP and debug the model until the ATP can run successfully. The contractor shall demonstrate successful execution of this ATP to the Air Force.

4.4.6.3 The contractor shall develop a speed control system using the digital model developed in 4.4.6.1. The new speed control system shall provide for stable operation of the facility while obtaining maximum acceleration and deceleration rates. These rates shall be limited only by the physical characteristics of the electrical drive machinery. The speed control system shall allow no more than 3 percent of setpoint speed overshoot in response to large/small step speed commands and step load changes. Within the limits of the machines, recovery time shall not exceed 6 seconds, or one cycle, whichever is longer. Steady-state speed stability and error shall be +0.1 percent of setpoint with up to 5 percent load changes. The new control system shall provide for power factor regulation on the drive motors and field current ramping for maximum torque if required. The new control system shall control field current to provide forced damping if possible. The new control system shall incorporate all safety and limit checks currently performed in the existing speed control system.

4.4.6.4 The contractor shall develop an acceptance test procedure to thoroughly test the control system developed in 4.4.6.3 against the model developed in 4.4.6.1 and against the CRF simulator to demonstrate the new control system. After Air Force approval of the ATP, the contractor shall perform this ATP and debug the control system until the ATP runs successfully. The contractor shall demonstrate to the Air Force successful execution of this ATP.

4.4.6.5 The contractor shall define all hardware, such as transducers and tachometers, required to implement the new speed control system. This definition shall include detailed procurement specifications.

BATTELLE ACTIONS AND RESULTS

In February 1984, Battelle initiated preliminary studies of the speed control drive system hardware and control algorithms to determine whether increased performance could be expected. This effort included developing a simple mathematical dynamic model of the drive system's DC motors and generators written in the Basic language. Because the heart of the speed control system is the DC machines and their field exciters, the simplified dynamic model primarily included representations of these machines. The effects of all AC machines and the compressor loads were greatly simplified.

With this model, various control concepts were evaluated. Initial results indicated that significant improvements could be expected from existing CRF drive system rotating hardware by implementing alternate control algorithms. In order to determine if the DC machine field exciters would be fast enough to accommodate a control system with increased performance, Battelle performed experimental transfer function analysis. The transfer function between the input command to the field exciter and the output of the shunt isolation amplifier was measured using random, small signal analysis. Its dynamic response was first order in nature with a time constant providing a break frequency of 20 Hz. This result indicated that the field exciters were fast enough to accommodate a new control system.

During this time, Battelle enlisted the services of Dr. Weimer of The Ohio State University Electrical Engineering Department. His expertise in large rotating power systems was utilized to investigate the feasibility of increasing the apparent damping of the 30,000 Hp. synchronous drive motor. This task was initiated because concerns were expressed by CRF staff that increasing the performance of the drive system could potentially cause oscillations on the drive shaft of the synchronous drive motor. Dr. Weimer's results established the feasibility of utilizing field control to increase the damping of the drive motor shaft and minimize or eliminate unwanted oscillations. The findings of the preliminary study prompted the Compressor Research Facility to request detailed modeling and control system analysis to further investigate possible changes to the variable speed drive system.

DETAILED CRF DRIVE SYSTEM MODEL AND CONTINUED CONTROL SYSTEMS ANALYSIS.

Following the Government's November 27, 1984, request to redirect efforts, Task I was modified to the following subtasks to be performed by Battelle.

1) Review three existing speed control models (AFIT, SCT, and CADRE).
2) Develop a complete drive system model of all hardware and implement on a microcomputer.
3) Design a new control system for CRF drive system.

The results from each of these subtasks are summarized below.

Existing Model Review - In preparation for developing and implementing an extensive model of the drive system, Battelle reviewed three existing models. During this effort Dr. Weimer provided additional expertise for the review of the AC machinery model representations. Battelle used several components of both the SCT and the CADRE models in the development of the new dynamic model. The SCT model provided valuable parameter identification information for the DC machinery models as well as accurate representations of the field exciters.

The CADRE model provided additional information used in the development of the 12,400 hp synchronous motor model as well as the combined IFC/30,000 hp synchronous motor model. No portions of the AFIT model were used because the model review indicated the SCT and CADRE models contained more complete information.

Complete Drive System Model - Initial efforts in this subtask focused upon identifying an appropriate microcomputer work station and software. The selected system must perform as an efficient development tool for the drive system model development and the drive system speed control development. In addition, it must perform as a durable and efficient interface tool between model users and the model itself. With these considerations in mind an IBM PC based microcomputer system was specified, purchased, and delivered to the Air Force.

The simulation language chosen for implementing the drive system model was the Advanced Continuous Simulation Language (ACSL). ACSL follows the standards established by the Simulation Councils' CSSL Technical committee in 1967. ACSL has full FORTRAN compatibility and unlimited program size. The use of ACSL as the drive system simulation language offers the advantages of direct representation of system component models and extensive interactive data output formats. The actual control algorithms are written in FORTRAN and incorporated within the ACSL model. Therefore, the control code exercised by the ACSL model simulation will be identical to that used on the CRF drive control computer. The use of ACSL resulted in a very flexible and easy to use drive simulation work station for both the developer of the model and the end user.

The actual mathematical, dynamic model of the drive system includes representations of the following hardware:

1) Both AC and DC field exciters including voltage and current limitations.
2) 12,400 hp synchronous motor.
3) DC motors and generators.
4) Induction Frequency Converter (IFC).
5) 30,000 hp synchronous drive motor.
6) Gearbox and compressor loads.

A full model description is provided in the document titled "Drive System Dynamic Model Documentation," dated February 13, 1987. Also included is a user's manual, programmer's manual, and technical reference manual.

In preparation for acceptance of the model by the Air Force, Battelle, in conjunction with CRF staff, prepared an Acceptance Test Procedure (ATP) and submitted it for approval on July 24, 1986. The ATP included comparing the Battelle developed model to actual data from historical data tapes of previous CRF compressor tests. A total of 32 variables were compared to actual data for three constant-speed tests and four transient conditions. Approximately 95 percent of all data matched within the required 10 percent of full-scale output. Those values that did not match were attributed to transducer calibration error or graphical scaling errors.

The actual hardware, the fully functional model, and all supporting documentation was delivered to the CRF on February 13, 1987.

Control System Design - The first step in the control system design involved performing a perturbation analysis of the DC machinery. Such an analysis provides valuable insight into how the system dynamics change depending on the value of the steady state operating conditions. Results of the analysis provided theoretical representations of the open loop transfer function between the field commands to the DC generator and motor fields and the rotational speed of DC motor shaft. This information is necessary for selecting appropriate controller functions that will provide consistent dynamic performance at all operating conditions.

The present CADRE control code was examined in detail and all safety features were identified so they could be incorporated within the new control code. Limited funding prevented further development of the new control codes.

Task J - Software Configuration Maintenance Support System (4.5)

OVERVIEW

The Branch computer facilities involve a large amount of software with extensive real-time interactions between computers and modules. The maintenance of these systems is obviously a very complex job. The Software Configuration Maintenance Support System (SCMSS) was developed to solve this problem by providing interactive access to an Intel System 2000 (S2K) database that contains information on each module and its interactions with other modules. The access requires the user to use S2K commands and to know how the data is stored in the database. This requires specialized S2K expertise, which is not always readily available. Improvements are needed to the SCMSS to simplify maintenance due to software changes, simplify the data access methods, and expand the database's information.

REQUIREMENTS

The contractor shall study the SCMSS and recommend improvements and alternatives to increase the productivity of the system, to make the system easier to maintain, to simplify its use, and to add more database information. The study shall include, but not be limited to, the following:

- Review of previously documented improvement possibilities,
- Review of the schema definition,
- Consideration of S2K system software enhancements,
- Inclusion of module comment and source code line counts,
- Inclusion of database file structure usage,
- Simplified update procedures to allow the SCMSS to keep pace with software changes,
- Maintenance of a production software library for all CRF test software on the Main computer.

The study and its recommendations will be reviewed for approval by the Air Force. After Air Force approval, the contractor shall implement the recommendations.

BATTELLE ACTIONS AND RESULTS

Battelle's study of the CRF SCMSS system included the following:

- An evaluation of the combination of IBM and Modcomp prescanners.
- A collection of information on the automation of obtaining Modcomp input data.
- A study of the methods used by the prescanners to obtain information from software headers.
- An evaluation of System 2000 PLEX database commands.

Upon completion of the study, Battelle's recommendations were submitted to the Air Force in July,1984. The modifications which were implemented include:

- Development of one prescanner (IBM and Modcomp).
- Modification of the prescanner input file to accept the same format input from the IBM and Modcomps.
- Modification of the IBM prescanner to allow for assembler code nested in Modcomp FORTRAN inline.
- Modification of the scanner to accept a more flexible header format and to gather additional data during the scanning.
- Modification of string definitions to optimize searching the database.
- Review of schema definitions.
- Modification of FORTRAN and Assembler scanners.
- Incorporation of SCMSS and Simulator software into the system.
- Development of a Plex load procedure and additional reporting capabilities.

Contract modification P00009 dated December 19, 1986, eliminated additional work on Task J.

TASK K - MAIN COMPUTER SUPPORT (4.6)

The original contractual requirement for this task was to provide operating system and application software support. Contract modification P00001, dated May, 1985, removed the operating system support requirement.

OVERVIEW

The Main computer is an IBM 4341 computer used during CRF testing for test article data reduction, storage, and display. During periods, the Main computer is used for software development, database applications, engineering simulations and analysis, and post test data reduction. Improvements and modifications were needed to the online CRF test software. In addition, test-related software needed to be developed, improved, or modified to enhance the computer's capabilities for support of post test analysis. Finally, S2K database applications needed to be developed, maintained, and improved.

Develop, Support, and Enhance S2K Database Applications (4.6.1)

REQUIREMENTS

The contractor shall develop, support, and enhance S2K database applications. The contractor shall also maintain and update the S2K system software and associated documentation, as required, based on periodic changes issued by the software supplier. Specific database applications that are required are a tape library database, a manuals database, a static data point database, and a Main computer usage accounting database. The contractor shall review the S2K Control/2000 option for possible use by these or other databases.

BATTELLE ACTIONS AND RESULTS

Battelle installed S2K release 11.0 single user mode on the IBM MVT system. The multi-user mode was being installed when the IBM operating system was upgraded from MVT to MVS. S2K was later installed on the MVS system.

Two Cobol report applications were converted to S2K Report Writer to delete the requirement for the Cobol compiler. Documentation was updated and the IBM operator was trained. Backup procedures were generated.

When S2K release 11.5 was installed, the tape and manuals databases were streamlined to remove erroneous and duplicated data. String functions were updated to remove unnecessary null entries and new strings were added to allow the operator to more efficiently accomplish database updates. The eight disk database files associated with each database were modified in size for more efficient data storage.

Predefined access methods for the tape library and manuals databases were eliminated. Batch access methods are now being used because they are faster, more user friendly and flexible.

Tape Library Database (4.6.1.1)

REQUIREMENTS

For the tape library database, the contractor shall study the current tape library documents and tape certification/recertification process and develop recommendations for a database.

BATTELLE ACTIONS AND RESULTS

Battelle studied tape library documents and the tape certification/recertification processes to develop a design for the CRF tape library database. Battelle designed the original schema and installed the first version of the tape library database (S2K release 2.9). Additional modifications were recommended in June, 1984. These modifications were approved by the Air Force and implemented.

Command strings were generated and incorporated into the database to facilitate update, query and reporting functions. A command was created to give the user interactive access to the database. User notes and system documentation were generated. Battelle installed S2K Release 11.0 in early, 1986, and converted the tape library database files to work with the new release. In May, 1986, upon conversion to the MVS operating system, Battelle added additional string functions to incorporate additional S2K Release 11.5 features, obtain additional information from the database and make the database maintenance duties easier. S2K Report Writers were developed to create reports thus helping to eliminate the requirement for a Cobol compiler in the CRF.

Open shop consultation on S2K was provided throughout the contract period.

Manuals Database (4.6.1.2)

REQUIREMENTS

The present manuals database shall be maintained by the contractor. Enhancements are required to add data fields to ease locating specific documents and to incorporate more document types.

BATTELLE ACTIONS AND RESULTS

Battelle's proposed enhancements to the Manuals database (S2K release 2.9) in June 1984, were approved by the Air Force.

Command strings were generated and incorporated into the database to facilitate update, query and reporting functions. A command was created to give the user interactive access to the database. User notes and system documentation were generated. Battelle installed S2K Release 11.0 in early 1986 and converted the Manuals database files to work with the new release. In May, 1986, upon conversion to the MVS operating system, Battelle added additional string functions to incorporate S2K Release 11.5 features, obtain additional information from the Manuals database and make the database maintenance duties easier. S2K Report Writers were developed to produce reports, thus helping to eliminate the requirement for an IBM Cobol compiler in the CRF.

Open shop consultation on S2K was provided throughout the contract period.

Static Data Point Database (4.6.1.3)

REQUIREMENTS

A database is needed of all static data points acquired during CRF testing. The contractor shall study the present data acquisition, storage, and retrieval process along with anticipated post test data analysis needs. Based on the study results, the contractor shall recommend a database to meet the analysis needs.

BATTELLE ACTIONS AND RESULTS

The Air Force decided not to implement this database system, therefore, the study was canceled.

Main Computer Usage Accounting Database (4.6.1.4)

REQUIREMENTS

The contractor shall study a partially completed database for Main computer usage accounting. The contractor shall determine the present status of the database and shall provide recommendations on changes needed to make the database operational.

BATTELLE ACTIONS AND RESULTS

The Air Force decided not to implement this database system, therefore the study was canceled.

Provide for Transient Data Acquisition (4.6.1.5)

REQUIREMENTS

The contractor shall make enhancements to the CRF Main computer online software to provide for transient data acquisition. The goal for transient data acquisition is to acquire scans of 150 channels of data at a rate of 400 scans per second for one minute periods. The data for each shall be acquired from the Auxiliary computer data link and stored on magnetic disk and on magnetic tape. Modifications are expected to be needed in the data link, disk storage, and retrieval, and tape storage and retrieval software. The contractor shall study the problem and make recommendations. The results shall be provided to the Air Force for approval prior to implementation. After Air Force approval, the contractor shall implement the recommendations.

BATTELLE ACTIONS AND RESULTS

The implementation of the transient data acquisition system incorporated changes in all data acquisition computers. This task is documented under Task A.

Statistical and Signal Analysis System (4.6.1.6)

REQUIREMENTS

The contractor shall procure and install a statistical and signal analysis system that will operate on the CRF Main computer under its MVS operating system and will perform the following data analysis functions: power spectral density, auto-correlation, cross-correlation, cross-spectrum magnitude and phase, coherence, and transfer. The system shall provide data manipulation to perform digital filtering, data windowing, data sampling, and data detrending.

BATTELLE ACTIONS AND RESULTS

Battelle studied several statistical analysis packages which were capable of fulfilling the requirements of this task. Upon completion of the study Battelle recommended SAS statistical software to meet the CRF needs. Upon Air Force approval Battelle purchased SAS software for installation on the IBM Main computer.

Systems and Applied Sciences Corporation is under contract with the CRF to provide Main computer systems support. They have been given responsibility for the installation of the SAS software specified and purchased by Battelle.

Maintain, Enhance and Develop Software for the Main Computer Needed to Support the Online CRF Data Acquisition System (4.6.2)

REQUIREMENTS

The contractor shall maintain, enhance, and develop software for the Main computer needed to support the online CRF data acquisition system. Software shall be documented and written in accordance with existing CRF standards. The following list identifies some of the modifications needed. For all of these, the contractor shall study the problem, the software, and the documentation to develop change recommendations.

BATTELLE ACTIONS AND RESULTS

Multi-tasking

Battelle was asked to rewrite the multi-tasking software.

The Main computer system is responsible for receiving, processing, storing, and displaying test article data acquired from the various computers in the CRF system. The test article data is gathered by the Data Acquisition Computer which passes it to the Auxiliary Computer, which sends the data to the Main computer. All of the data coming from the DAC cannot be processed in real time on the IBM. However, all the data is stored on magnetic tape for analysis and display at a later time. The software executing during compressor testing is a multi-tasking system that:

- Downloads database information to the Modcomp computers.

- Allows the engineers to make database changes online during testing.

- Stores the database and database changes made during the test on magnetic tape to facilitate post-processing.

- Keeps a directory of all the data files stored on tape during a test.

- Allows the engineers to start channel check and pressure calibration software, process the data as it comes from the AUX computer and display the results.

- Accepts raw data from the AUX computer and stores it all on magnetic tape for future playback and analysis.

- Allows the engineers to choose any display format they wish to see during a test, and lets them change displays rapidly as the need arises.

- Allows the engineers to make a hardcopy of their displays at any time during a test.

- Processes enough data in real time to allow an update rate of approximately every three seconds on the engineer's displays.

- Handshakes with the AUX and Monitor computers so that the engineers are aware of the data acquisition system's status.

After a test, the Main is the primary focus for post-processing and analysis of data collected during a test.

Battelle, with Air Force inputs, designed multi-tasking facilities to support the new design of the online software. These facilities included software to attach and detach tasks from other tasks as well as facilities to allow these tasks to wait on each other and events occurring in the system, post each other to notify tasks when events occurred, and pass needed information from task to task. Upon completion of the design and development of these facilities, a major redesign of all online and post-processing software was performed. Battelle rewrote three large, complex IBM Assembler tasks using software engineering techniques to structure the software. FORTRAN was primarily used with Assembler code being used for speed. The three tasks which Battelle rewrote included data link software, disk storage and retrieval software, and tape storage software. All tasks described below were written to facilitate future modifications and enhancements. The internal documentation is very clear and complete.

The old data link software was written entirely in IBM Assembler as a single 3000 line module. Its function was to read and write to both the Monitor and AUX data links. Battelle broke this task up into six tasks, with a separate task to handle each link. Assembler code was only used to handle the I/O. FORTRAN code was used for the protocol and logic. This software is now easier to understand and maintain. The old disk storage and retrieval software was written in IBM Assembler and was not broken up into separate, functionally strong subroutines. This software was the known source of many problems in the online software. Battelle separated data storage and retrieval into three separate tasks. One task responds to any task in the online system which needs to read or write a database record. Another task is then directed to perform the actual I/O and return the needed information to the calling task if the request was a read operation. Another task reads and writes raw data from the AUX computer when the tape storage task is too busy. The I/O is redirected to disk when it is detected that the tape storage software is busy, which is usually the case when tape storage has filled up one tape and is in the process of mounting another.

Battelle broke the tape storage software up into four tasks. Two FORTRAN tasks control the logic to wait on other tasks and format the data to be written to tape and the tape directory. Two assembler tasks were created to write the data to tape and the tape directory.

The old data acquisition software used a buffering scheme in which data came from the link and was buffered to a disk file. As new buffers were written to disk, the oldest buffers would be read from disk and sent to tape storage. This detour of the data to disk before being written to tape was eliminated in the new software design. The new buffering scheme allocates 20 buffers to two queues, the data link queue and the tape storage queue. One task reads data into the buffers in the data link queue, and another task moves the data from a buffer in the data link queue to a buffer in the tape storage queue and alerts the tape storage task to write the buffer to tape. If one tape has been filled and the tape storage software is waiting for the operator to mount a new one, the buffers in the data link queue will be written to disk temporarily. When tape storage is ready to receive data again, the data will be read from disk into the tape storage queue buffers, and tape storage will be notified to write the data to tape.

The fact that the data is not written to disk and read back from disk before it is written to tape helped to speed up the software. This helped the Main software to be fast enough to handle transient data (discussed in Task A).

Task Communications

The task communication routines used by the multi-tasking run-time software were developed by Battelle in conjunction with the Air Force. These routines allow tasks to pass information to one another so that critical timed event sequences within the software are properly started, coordinated, scheduled, and stopped. Five tasks were developed to perform the following functions:

- Place a task on the ready queue,
- Take a task out of the ready queue,
- Allow a task to wait on an event or events,
- Allow a task to notify a waiting task that an event has happened,
- Allow a task to retrieve information from another task.

These routines were incorporated into all Main run-time and post-processing software.

Reduction Software

Battelle implemented changes to the reduction software to correct floating point to fixed data conversion problems. Software changes were made to check the performance constants the data operator can set to see whether performance and/or statistical software should be executed. Changes were made to the EUC routines to convert degrees F to degrees R. The reduction software was modified to handle abort data.

The reduction task initializes several common blocks when it is attached. Some of the information in these common blocks, such as, performance constants, can be changed by the data operator during a run. This would mean that the information in the common blocks would become outdated as the run progressed. In the old design the reduction software would be stopped and restarted when information in these common blocks was affected. Battelle rewrote the software so that it could be notified of the change and branch back to its initialization code when needed. This eliminated the need to stop and restart the reduction software during a run, which saves time.

Miscellaneous Support

The master control task was one large assembler routine. Battelle broke it up into 20 small FORTRAN subroutines to make the software more maintainable.

When taking data during a run, each file which is written to tape has an associated entry in the tape directory which is kept on disk. When these run time tapes are merged, some of the information, like tape numbers, must be changed. Battelle designed, wrote, and tested the tape directory maintenance program to satisfy this need. With this program a user can change, add new or delete old entries. Battelle also wrote a program to print the tape directory.

Battelle totally rewrote the B2X and X2B utility routines. B2X changes an integer number into an EBCDIC character representation, while X2B does the reverse of this operation.

A watchdog task was added to automatically check the CRT and reduction tasks. If a task should fail, this watchdog task will instruct the master control program to stop and restart it.

IBM Share routines were installed on the IBM MVT system.

Battelle modified Mach number correction software.

Battelle modified the software which sorts through the tape directory data to display information to a user. Several errors were found and corrected in the build directory software which is executed from any of the CRT tasks. It was also found that the tape storage software was making incorrect entries in the tape directory. These problems were corrected. Battelle rewrote the tape storage software and broke out the directory logic into separate tasks.

Battelle was asked to keep the Main software libraries in order. This responsibility included adding newly developed and modified routines to the proper libraries, making backups before and after any library changes, generating cross-reference lists of which tasks use what subroutines, making sure that any subroutines that were modified were tested with all tasks in which they are used, updating the JCL to compile and link the software as required, keeping a current set of listings, and generating a sequential dataset of all Main run-time software.

Battelle added a new help screen to the CRT tasks to instruct the user about the new commands that have been added.

Battelle continually conducted open shop consultation for members of the Data Acquisition Group and other new personnel (government or contractor) working in the CRF.

Battelle supported the first GESRO channel checks to help the engineers with the new software.

Changes were made to subroutine SPTITL of the print software to put titles on post-processing static printouts.

Set Configuration Code Reading Number (4.6.2.1)

REQUIREMENTS

The Data Engineer needs the capability to set the configuration codes reading number from the Main computer alphanumeric terminal.

BATTELLE ACTIONS AND RESULTS

Battelle's study into the above requirement revealed that resetting of the configuration code reading number is best performed at the DAC. Battelle modified the online software in the DAC computer to display a menu that gives the DAC operator the opportunity to reset the compressor configuration code reading number, channel check number and pressure calibration number to zero.

Database Parameter Display (4.6.2.2)

REQUIREMENTS

Several modifications are needed to the Main computer alphanumeric terminal software to display more database information, to simplify their use and to provide more data to the user.

BATTELLE ACTIONS AND RESULTS

Battelle made program design changes to modify the online software so that the CRTs could display additional database information. A problem was encountered in that each of the five different types of database file structures required a different display format. No further steps were taken to address the problem.

Tape Directory Configuration Codes (4.6.2.3)

REQUIREMENTS

The present online software cannot set any of the configuration code fields in the Main Tape Directory which are calculated by the data reduction modules.

BATTELLE ACTIONS AND RESULTS

Battelle and the Air Force determined that the Main online software did not need to set the configuration codes since they could be available from the DAC computer. Battelle modified DAC software to send configuration code data to the Main computer in the key area of the ICOUNT database file structure. The Main computer Tape Storage and Tape Directory software were modified to read the configuration code data and put it into the tape directory.

IBM Standard Label Tapes (4.6.2.4)

REQUIREMENTS

The test article data tapes written by the Main online software need to have IBM standard labels to simplify tape use and to minimize operation mount errors.

BATTELLE ACTIONS AND RESULTS

Battelle studied this requirement and determined that it would not be cost or time effective to make the required software changes to use IBM standard label tapes. Standard IBM Input/Output access methods were evaluated for use with these tapes and it was concluded that they would be too slow or require too many data definition cards in the existing procedures used to execute the online software.

Changes were made to the Standard Format Tape (SFT) generation software and SFT processing software so that these tapes could be created and used with standard IBM labels.

Post-Processor Software Modifications (4.6.2.5)

REQUIREMENTS

The Main computer's pressure calibration and channel check software need the capability to run from a post-processor tape. This will require modification to the online and post-processor software.

BATTELLE ACTIONS AND RESULTS

This subtask was accomplished as a by-product of the redesign and recoding of the online software. Battelle isn't aware of any problems which exist.

Simultaneous Print Requests (4.6.2.6)

REQUIREMENTS

Simultaneous print requests by online terminals are not serviced properly by the print modules. Conflicts can also occur if static data points are taken too rapidly. Changes are needed to resolve these problems.

BATTELLE ACTIONS AND RESULTS

Battelle studied and accomplished this subtask by adding an I/O flag to the intertask communication array. When any task in the online software wants to perform FORTRAN I/O, it must first test and set the I/O flag in the intertask communication array. If that flag is set, then the task must wait to do its I/O. When a task is done with FORTRAN I/O, it will reset the flag. Battelle also added a command to CRT01 to manually reset the flag in case a task aborts before resetting it.

Main Tape Directory Sorting (4.6.2.7)

REQUIREMENTS

Additional sorting of Main Tape Directory information by an online terminal user is needed to ease directory use.

BATTELLE ACTIONS AND RESULTS

Battelle completed this subtask by studying the requirements for additional sorting of the Main computer tape directory, then, discovering and correcting software search algorithims. Additional capabilities were added to the tape directory software by allowing it to also search/sort on tape numbers and dates.

Maintain, Enhance, and Develop Software for the Main Computer Needed to Support the Pre-test and Post-test Engineering Simulation and Analysis of Compressor-Related Data (4.6.3)

REQUIREMENT

The contractor shall maintain, enhance, and develop software for the Main computer needed to support the pretest and post-test engineering simulation and analysis of compressor-related data. Specific tasks include the conversion of a digitizing program to run on the Main computer, conversion of a structural analysis program to run on the Main computer, development of software to create standard format test article data tapes, development of software to merge test article data tapes, and development of software to merge facility historical data tapes.

BATTELLE ACTIONS AND RESULTS

Post-Processing

The post-processing software was written by the Air Force to allow a user to interact with the run-time software and process old data from Main data tapes. Post-processing software sends the data through the reduction software, and displays the resulting engineering units on a CRT or as a hardcopy. Post-processing software was rewritten to use the new task communication routines, and to be able to process the data from tapes that are now stored in a different format than previously. Battelle gave the software the necessary logic to distinguish between the formats, keeping the post-processing software in a state where it could process old or new run-time tapes.

Battelle added the capability for a person to use post-processing software when generating a standard format tape. This gave users the ability to make standard format tapes in either an interactive or batch mode. The batch mode of processing is much faster, but the interactive mode comes in handy when the user does not know before hand what data is to be put on tape.

Battelle created a new version of the post-processing software which allows a user to process forward and backward within a reading number.

Battelle created the FDA and F100 libraries to make Standard Format Tapes from FDA and F100 compressor test data. This effort involved modifying and incorporating the reduction software at the end of each test with the current post-processing software being used in the Main computer production libraries.

Plotting System

Battelle created and supported the tape plotting software system used in the CRF. The plotting system processes Facility Historical, High Speed, and Standard Format Tape (SFT) data to produce x-y plots of user-selected variables. Facility Historical Data Tapes contain facility information collected by the Monitor computer during actual compressor testing. High

Speed tapes contain 20 variables that are collected on the FCC1 computer at a 10 milliseconds scan rate. Standard Format Tapes contain the data needed to plot compressor maps or specific test article performance parameters. All three plotting options allow the user to read a data tape to disk, create a plot specification file where the user inputs what variables are to be plotted on each plot, generates the requested plot and outputs the plot vectors to a plotter or a file that can be plotted later on the available devices in the CRF.

The Standard Format Tape plotting system also incorporates a scan option. It allows the user to scan the tapes for header information, and up to five variables before printing the associated values. Another option allows the user to read selected reading numbers from a group of Standard Format Tapes, and output the "mixed data" to a disk file for plotting, thus allowing the user to make plots of different modes of data. Battelle created standard batch jobs the computer operator can run at the end of the testing day. These jobs read all the static data type information from the run-time data tapes created that day to a Standard Format disk file and then plot the information. Battelle wrote the first High Speed plotting program to run on the FCC1 computer using the PLOT10 graphics library and a Tektronix terminal. Battelle moved the High Speed plotting system to the Main computer so that it could run faster and because the Main computer had easier user access. The system was converted to use the DISSPLA language. Battelle then designed and implemented a plotting system to handle Facility Historical and Standard Format tapes. Battelle took the three tape plotting systems and merged them into one system called TPLOT. Battelle gave this system the capability to print data as well as plot it.

When the conversion to the IBM MVS operating system occurred, TPLOT was further enhanced to:

- Incorporate procedures to process classified data.

- Modify the internal reader jobs to allow the user to create a plot or "plot file" from the same program.

- Modify Standard Format tape plotting routines to allow user input graph labels, graph legends and positions and plot titles.

- Enhance input variable screening processes to allow for faster processing of transient data from Standard Format tapes.

- Add additional DISSPLA options.

Digiplt (4.6.3.1)

REQUIREMENTS

Digiplt, originally written to run on the CDC computers, allows interactive digitizing using Tektronix equipment. It has been converted to also run on playback requirements to develop recommendations for merging these tapes on the Main computer and maintaining a tape directory of tape information. Consideration shall also be given to the method of playing back tapes after they have been merged.

BATTELLE ACTIONS AND RESULTS

Battelle developed the first version of software to merge Facility Historical data tapes on the IBM MVT system. Systems Research Laboratory is now converting the software to the IBM MVS system and making enhancements.

BATTELLE ACTIONS AND RESULTS

Battelle designed and implemented the Standard Format Tape Generation (SFTGEN) software on the IBM computer system. This software incorporates software engineering techniques in conjunction with the CRF multi-tasking routines that allow different tasks to execute simultaneously. The software reads Main Computer run-time data tapes, processes them through the online software in a batch or interactive mode and then creates a Standard Format Tape for analysis. Standard Format Tapes contain documentation, header, units, delete codes and engineering values data for each file. The four data types (monitor, static, transient, and abort) can be sent to the tape, but each tape will have only one type of data stored for a given standard format tape generation run. The software can select start and stop times within a millisecond for transient and monitor data. All header types can be selected for transfer. The software provides informative written output, error messages, and internal program documentation.

Many enhancements have been added to the software in response to Air Force priority task lists to keep the SFTGEN software current with CRF needs.

Merge Main Data Tapes (4.6.3.4)

REQUIREMENTS

The present Main online software requires a blank data tape each time the software is started. This can result in multiple data tapes for a single test. In addition, due to operational errors, invalid entries can occur in the Main Tape Directory maintained on disk. The contractor shall study the existing software, tapes, and operational procedures to develop recommendations for merging these data tapes and for modifying the Tape Directory.

BATTELLE ACTIONS AND RESULTS

Battelle created the directory maintenance and merge Main data tape software on the IBM MVT system and then participated in its conversion to the IBM MVS system. Systems Research Laboratory has now been given the task of completing and enhancing this software.

Merge Facility Historical Data Tapes (4.6.3.5)

REQUIREMENTS

The present Monitor online software records facility historical data on tape for post-test analysis and playback. The recording density is relatively low which results in relatively high tape usage. In addition, there is no automatic directory of data for correlating data tapes with last runs or run events. The contractor shall study the existing software, documentation, and

Prime computers. The contractor shall study the existing versions and develop recommendations for providing this capability on the Main computer using the DISSPLA graphics software package.

BATTELLE ACTIONS AND RESULTS

The Digiplt software was obtained from the Materials laboratory where the software was running on a Prime computer. At the CRF, Battelle's task was to convert the software to run on the CRF IBM MVT system. The software was loaded on the IBM, software modifications were made, and compile and link procedures were developed and executed. Upon execution of the link step, it was found that unidentified external routines were encountered. Further research found that the unidentified externals were extended PLOT10 library routines to which the CRF did not have access.

This task was placed on hold by the Air Force. It was anticipated that SAS software implementation would replace this requirement.

MESH3 (4.6.3.2)

REQUIREMENTS

MESH3 and its related analysis programs originally written to run on CDC computers, provide structural analysis capabilities which are not available on the CRF Main computer. The contractor shall study the existing software and develop recommendations for converting this software to run on the Main computer.

BATTELLE ACTIONS AND RESULTS

The MESH3 software was reviewed, documentation generated and comments incorporated into code as required. The task was then placed on hold by the Air Force due to the amount of work which was going to be required to make the custom software operational on the IBM computer.

Further study indicated that the CRF shall purchase an off-the-shelf, maintained software package to replace the MESH3 software. SAS software has the potential to meet at least part of this requirement.

Generation of Standard Format Tape Software (4.6.3.3)

REQUIREMENTS

Present CRF test article data tapes are written in a format that is not generally readable by other computer systems. In addition, there is data on the tapes that is not of general interest. However, when the CRF runs a test article for a contractor, data tapes of the test results are required. The contractor shall study the existing software, documentation, and data tape format/content requirements in order to provide recommendations on developing this capability.

Install and Utilize two CRT terminals to provide adequate Interactive Access to the CRF Main Computer (4.6.4)

REQUIREMENTS

The contractor shall install and utilize two CRT terminals to provide adequate interactive access to the CRF Main computer. These terminals shall be IBM 3277 compatible so that they will interface to the IBM 3272 terminal controller on the CRF Main computer. The contractor shall provide for the CRT terminal maintenance for a six month period.

BATTELLE ACTIONS AND RESULTS

In June 1984, two IBM 3277 terminals and keyboards were purchased to facilitate interactive access to the IBM computer.

Install, Enhance and Maintain the IBM MVS Operating System (4.6.5)

REQUIREMENTS

The contractor shall install, enhance, and maintain the IBM VM and/or MVS operating systems. While these operating systems are not now in use at the CRF, conversion from MVT is likely within the next 24 months.

BATTELLE ACTIONS AND RESULTS

In April 1986, the IBM computer operating system was upgraded to the Multiple Virtual Operating System (MVS) by System and Applied Sciences Corporation (SASC). Battelle's task was to make the application software running with MVS. This proved to be a much larger job than the Air Force had anticipated. The majority of the application software would not compile with the new version of FORTRAN that came with MVS.

Each of the four hundred run-time software routines was reviewed which incorporated approximately 70,000 lines of code. Each routine was modified to compile and link with the new version of FORTRAN. Tasks were linked together and testing was performed. The assembler routines which read the Modcomp 1950 links posed the biggest problem. The MVS operating system wasn't as tolerant of existing idiosyncrasies as the MVT operating system. Changes were made to the channel programs which read from and wrote to the 1950 link. Pratt and Whitney programmers who originally developed the channel programs that talked to the 1950 link were called. They informed us that the 1950 link created interrupts on the link at a much faster rate than the new operating system thought was normal, so the operating system locked up. A 'zap' to the operating system's threshold level for this type of interrupt was installed by SASC which allowed the IBM and the Modcomps to talk to each other. The post-processing software was then converted. (There remains to be a number of application programs in the CRF which have not been converted to run on the MVS system as of August 1, 1988.)

GLOSSARY

ADPE	Automated data processing equipment
AFB	Air Force Base
AFSC	Air Force Systems Command
AFWAL	Air Force Wright Aeronautical Laboratories
ATP	Acceptance Test Procedure
AUX	Auxiliary computer
BPI	Bytes per inch
CRF	Compressor Research Facility
CRFNET	CRF Computer Communications Network
CRT	Cathode Ray Tube
CSP	Command String Processor
DAC	Data Acquisition Computer
FCC	Facility Control Computer
FCC1	Facility Control Computer 1
FCC2	Facility Control Computer 2
FHD	Facility Historical Data
GCOM	Global Common Database
GKS	Graphics Kernal System
hp	Horsepower
HPDAS	High Performance Data Acquisition System
IBM	International Business Machines
IGP	Interactive Graphics Processor
IGV	Inlet Guide Vane
IOIS	*Input/Output Interface System*
ISPF	Interactive System Productivity Facility
LDV	Laser Doppler Velocimeter
LTA	Laser Transit Anemometer
Main	Main Computer
Masscomp	Masscomp Computer
Max	Modcomp Operating System
Max III	Modcomp II Operating Systems
Max IV	Modcomp Classic Operating System
Modcomp	Modular Computer Systems
Monitor	Monitor Computer
MVS	IBM's Multiple Virtual Operating System
PCAL	Pressure CALibration
PLC	Programmable Logic Controller
PLC1	Programmable Logic Controller #1
PLC2	Programmable Logic Controller #2
POTX	Propulsion Technology
Preston	Analog to digital signal converter
Ramtek	Color graphics generator
rpm	Revolutions per minute
RTU	Masscomp real time unix operating system
SASC	Systems and Applied Sciences Corporation
SRL	Systems Research Laboratories
S2K	System 2000 database
TAC	Test Article Control Computer
TAC1	Test Article Control Computer 1
TAC2	Test Article Control Computer 2

TRV	Traverse table
TSO	Time Sharing Option
UPS	Uninterruptable Power System
WPAFB	Wright Patterson Air Force Base
WRAIS	Wide Range Analog Input System